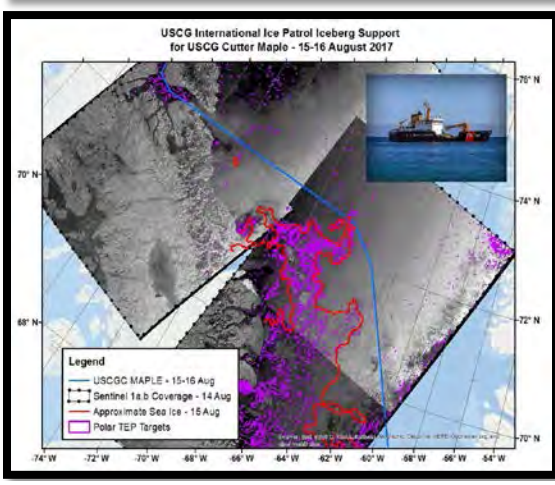
Homeland Security

United States Coast Guard

Report of the International Ice Patrol in the North Atlantic



2017 Season
Bulletin No. 103
CG-188-72

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Report of the International Ice Patrol in the North Atlantic
Season of 2017
CG-188-72

Forwarded herewith is Bulletin No. 103 of the International Ice Patrol (IIP) describing the Patrol's services and ice conditions during the 2017 season. With 1008 icebergs drifting into the transatlantic shipping lanes, 2017 was the 19th most severe Ice Season on record dating back to 1900 and the fourth extreme Ice Year in a row. While the number of icebergs was high, the most significant environmental event was the rapid increase in the number of icebergs entering the transatlantic shipping lanes over a two week period in March and April as a result of two intense low pressure systems. The Ice and Environmental Conditions section presents a discussion on this period as well as the meteorological and oceanographic conditions that led to another extreme season.

IIP began operational implementation of commercial synthetic aperture radar satellite reconnaissance for iceberg detection and identification as described in IIP's 2016 Satellite Reconnaissance Concept of Operations (CONOPS). Beginning on 24 January, and throughout the remainder of the Ice Season, watch standers in IIP's Operation Center in New London, CT used Iceberg Detection Software to analyze satellite imagery for the first time in IIP's 104-year history. Similar to transitions from ship to aerial reconnaissance beginning in 1946 and the introduction of radar for aerial reconnaissance in 1983, this event marks a historic shift in IIP reconnaissance operations.

Further, IIP continued its pursuit to remain a world leader in ice hazard monitoring, modeling, and charting in 2017. Whether leading the Iceberg Committee of the International Ice Charting Working Group (IICWG), presenting at the Glacial Ice Hazards Work Group in St. John's, Newfoundland, coordinating ice reconnaissance with our North American Ice Service partners - the Canadian Ice Service and National/Naval Ice Center, or examining advances in modeling, machine learning, and cloud computing, IIP sought to advance iceberg reconnaissance, tracking, and information dissemination to ensure the safety of mariners plying the waters of the North Atlantic.

Finally, on 11 August 2017, I relieved CDR Gabrielle McGrath as the 56th Commander of the International Ice Patrol. On behalf of the dedicated men and women of IIP, I offer this report on the 2017 season.

K. L. Serumgard
Commander, U. S. Coast Guard
Commander, International Ice Patrol

International Ice Patrol
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Previous IIP Annual Reports may be obtained from the following sources:

- IIP website: http://www.navcen.uscg.gov/?pageName=IIPAnnualReports
- Printed and bound Annual Reports (1963 – 2015) can be ordered from the National Technical Information Service (NTIS) website at http://www.ntis.gov.

Cover art (clockwise from top): Two HC-130J aircraft on deck in St. John's, Newfoundland during IRD 3; large iceberg sighted by USCGC MAPLE in Baffin Bay; collage representing International Ice Patrol's 2017 Satellite Integration.

Abbreviations and Acronyms

AIS	Automatic Identification System
AMS	Aviation Mission Specialist
APN-241	HC-130J Tactical Transport Weather Radar
ASEC	USCG Air Station Elizabeth City
BAPS	iceBerg Analysis and Prediction System
CG-5PW	USCG Director of Marine Transportation Systems
CCG	Canadian Coast Guard
CCGS	Canadian Coast Guard Ship
C-CORE	A not-for-profit research and engineering organization in St. John's, Newfoundland
CIIP	Commander, International Ice Patrol
CIS	Canadian Ice Service, an operational unit of the Meteorological Service of Canada
CONOPS	Concept of Operations
DMI	Danish Meteorological Institute
ELTA	ELTA Systems Ltd., a group and a wholly-owned subsidiary of IAI (Israel Aerospace Industries) specifically referring to the ELM-2022A Airborne Maritime Surveillance Radar aboard the HC-130J
EPIRB	Emergency Position Indicator Radio Beacon
ERMA	Environmental Response Management Application, NOAA
ESA	European Space Agency, owner of the Sentinel-1a satellite
F/V	Fishing Vessel
ft	Feet
HC-130J	USCG Long Range Surveillance Maritime Patrol Aircraft
IIP	International Ice Patrol
IRD	Ice Reconnaissance Detachment
KML	Keyhole Markup Language
kts	Knots
m	Meters
M/V	Motor Vessel
mb	Millibar
MCTS	Marine Communications and Traffic Service, Canadian Coast Guard
N	North Latitude

NAIS	North American Ice Service
NAOI	North Atlantic Oscillation Index
NAVAREA	Navigational Area
NAVTEX	Navigational Telex
NGA	U. S. National Geospatial-Intelligence Agency
NIC	U. S. National Ice Center
NL	Newfoundland
NM	Nautical Mile
NOAA	National Oceanographic and Atmospheric Administration
NOTSHIP	Notice to Shipping
NTIS	National Technical Information Service
NWS	National Weather Service
OPAREA	Operational Area
OPC	Ocean Prediction Center, NOAA
OPCEN	Operations Center
PAL	PAL Aerospace, Ltd, a commercial aerial reconnaissance provider based in St. John's, Newfoundland.
POD	Probability of Detection
RADARSAT-2	Canadian C-Band SAR satellite system, owned and operated by MacDonald, Dettwiler, and Associates.
Radiofax	Radio Facsimile
RMS	Royal Mail Steamer
SafetyNET	Inmarsat-C Safety Net, automated satellite system for promulgating marine navigational warnings, weather, and other safety information.
SAR	Synthetic Aperture Radar
Sentinel-1a	ESA C-Band SAR satellite system
SIM	Standard Iceberg Message
SITOR	Simplex Teletype Over Radio
SOLAS	Safety of Life at Sea
SST	Sea Surface Temperature
SVP	Surface Velocity Program
TEP	Thematic Exploitation Platform
USCG	United States Coast Guard

USCGC	U.S. Coast Guard Cutter
W	West Longitude
WWNWS	World Wide Navigation Warning System

Introduction

This is the 103rd annual report of the International Ice Patrol (IIP), describing the 2017 Ice Season that is currently the nineteenth most severe ice season on record since 1900. It contains information on IIP operations and environmental and iceberg conditions in the North Atlantic between February and August of 2017. IIP deployed Ice Reconnaissance Detachments (IRD) to conduct aerial reconnaissance in search of icebergs in the North Atlantic and Labrador Sea, primarily operating from St. John's, NL using U. S. Coast Guard (USCG) Long Range Surveillance Maritime Patrol Aircraft (HC-130J) from USCG Air Station Elizabeth City (ASEC). In addition to this aerial reconnaissance data, IIP received iceberg reports from other aircraft and mariners in the North Atlantic as well as incorporating satellite image analysis. Of particular note, 2017 marks the first year IIP processed satellite imagery in house for inclusion in the iceberg sighting database and modeling. IIP personnel analyzed iceberg and environmental data using the iceberg drift and deterioration model within the iceBerg Analysis and Prediction System (BAPS) at the IIP Operations Center (OPCEN) in New London, CT. In accordance with the North American Ice Service (NAIS) Collaborative Arrangement, IIP used BAPS to produce an iceberg chart and a text bulletin using the model output of predicted drift and deterioration. These iceberg warning products were then distributed by multiple means to the maritime community. IIP also responded to individual requests for iceberg information in addition to these routine broadcasts.

IIP was formed after the Royal Mail Steamer (RMS) TITANIC sank on 15 April 1912. Since 1913, with the exception of periods of World War, IIP has monitored the iceberg danger in the North Atlantic and broadcast iceberg warnings to the maritime community. The activities and responsibilities of IIP are delineated in U.S. Code, Title 46, Section 80302 and the International Convention for the Safety of Life at Sea (SOLAS), 1974.

For the 2017 Ice Season, IIP was under the operational control of the Director of Marine Transportation (CG-5PW), Mr. Michael D. Emerson. CDR Gabrielle G. McGrath was Commander, IIP (CIIP) until 11 August 2017, when CDR Kristen L. Serumgard assumed the duties as CIIP.

For more information about IIP, including historical and current iceberg bulletins and charts, visit our website at www.navcen.uscg.gov/IIP.

Ice and Environmental Conditions

Operational Area

IIP is responsible for guarding the southeastern, southern, and southwestern limits of the region of icebergs, in the vicinity of the Grand Banks of Newfoundland. In conjunction with our North Atlantic Ice Services (NAIS) partners, the Canadian Ice Service and United States National Ice Center (NIC), IIP examines the environmental, meteorological, and climatological data to develop accurate iceberg warning products in the IIP Operational Area (OPAREA) (**Figure 1**). The confluence of the cold Labrador current and warm Gulf Stream and North Atlantic currents, make this area especially challenging for reconnaissance due to frequent fog and the presence of small-scale oceanographic features.

Ice Year Summary
Season Severity

During the 2017 Ice Year, 1008 icebergs (not including bergy bits or growlers) crossed south of 48°N latitude marking the fourth “extreme” year in a row (IIP, 1994). Icebergs south of this latitude represent a particularly hazardous situation for transatlantic shipping. By definition, the “Ice Year” spans the time period between 01 October of the previous year and 30

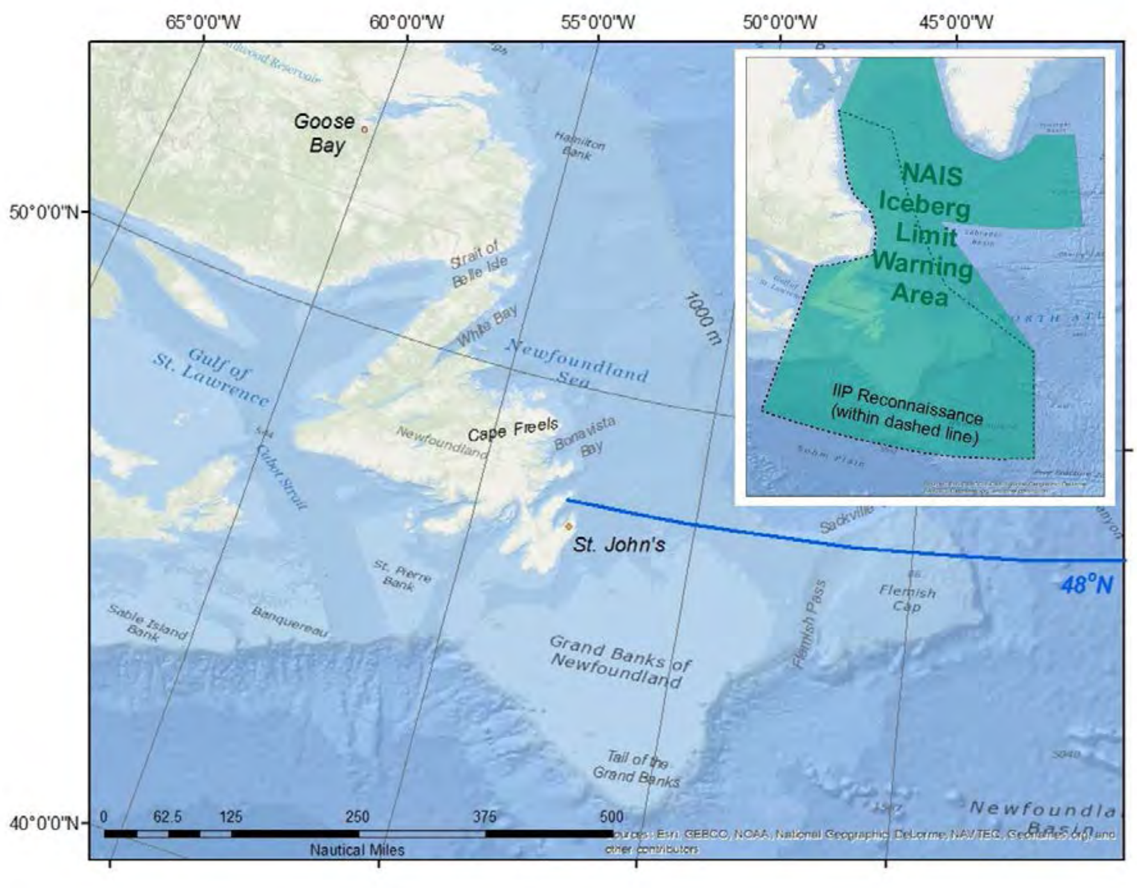

Figure 1. International Ice Patrol Operational Area (OPAREA). The region shaded in green represents the NAIS Iceberg Limit Warning Area. The region within the dashed line is the IIP iceberg reconnaissance area. IIP measures season severity based on latitude 48°N, typically considered the northern boundary of the transatlantic shipping lanes.

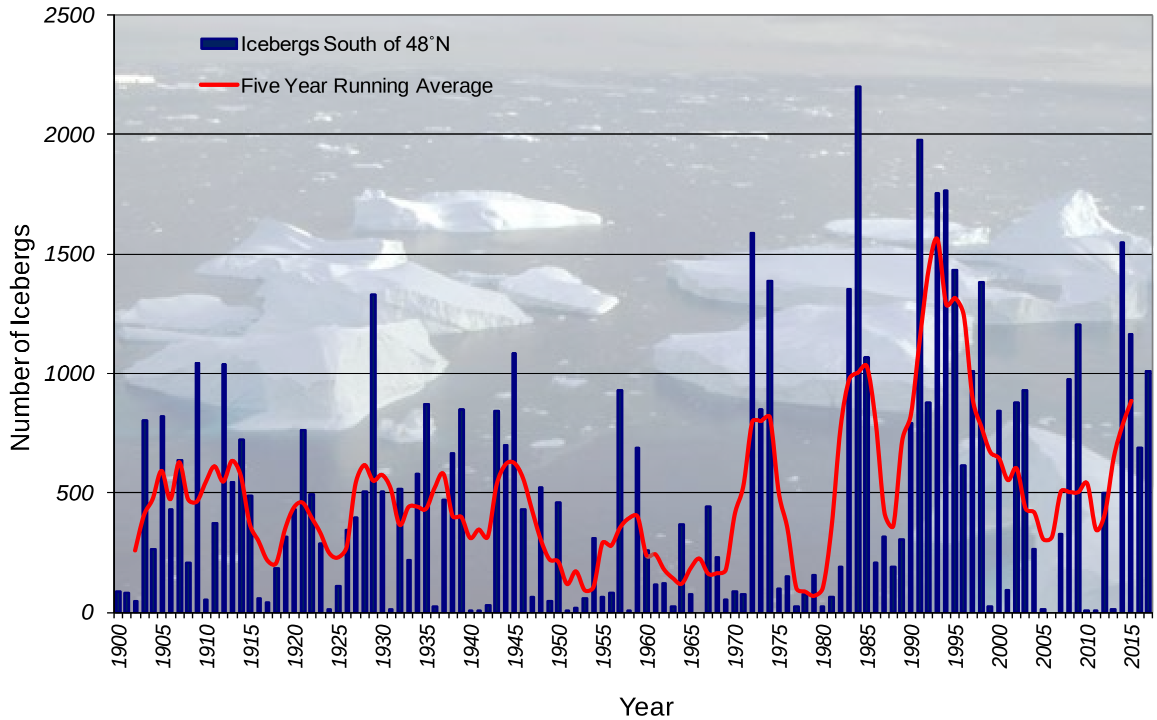

Figure 2. Icebergs crossing 48°N latitude and 5-year running average (1900-2017).

September of the current year. From 1900-2016 the average number of icebergs south of 48°N in an Ice Year is 486. **Figure 2** shows the historical variability for this measurement from 1900 to 2016 (blue columns) along with the five-year running average (red line). Variations arise due to actual changes in season severity, but also as a result of modifications to sighting methods. In terms of icebergs south of 48°N, the 2017 Ice Year ranked as the 19th most severe year since 1900.

Other season severity indicators include 'Season Length' and 'Iceberg Distribution'. Season length is defined as the number of days icebergs were present south of 48°N. In 2017, icebergs were present south of 48°N for a total of 193 days. This included the time periods from 14 February-08 August, from 16-24 August, and from 18-25 September.

Iceberg distribution is another indicator of season severity and is related to the area encompassed by the Iceberg Limit south of 48°N. The average Iceberg Limit area for 2017 was 60,102 square nautical miles (NM^2). Due to extreme storm systems that passed through IIP's OPAREA in late March and early April, the Iceberg Limit expanded southward rapidly, reaching its southernmost extent of 40°15′N on 16 April 2017, over two months earlier than in 2016 but contracted rapidly throughout the remainder of April. In general, iceberg distribution was focused around Newfoundland with a southern extent 15 NM further north than in 2016. The Iceberg Limit reached its easternmost extent of 40°30W longitude on 04 June and its westernmost extent of 62°31'W on 15 June. The iceberg distribution in 2017 had a significant impact on maritime operations in the region.

Pre-season Predictions

The Canadian Ice Service (CIS) issued a Seasonal Outlook for Winter 2016-2017 on 01 December 2016 based on the analog years 1998/1999 and 2012/2013, which showed similar atmospheric and sea surface temperature (SST) conditions (CIS, 2016a). Since 2017 was forecasted to be a "La Niña" year, average air temperatures were expected to be above normal. In addition, a forecasted negative North Atlantic Oscillation Index (NAOI), supporting predominantly onshore winds, predicted below normal sea ice coverage for both the Labrador and Newfoundland coasts.

With forecasted below normal sea ice coverage, CIS also projected that the arrival of icebergs would be delayed until early March and that the overall iceberg population would be diminished for the year (CIS, 2016b).

Ice Year Environmental Condition Overview

With the exception of 2 weeks in February, when sea ice coverage exceeded median coverage in Newfoundland and

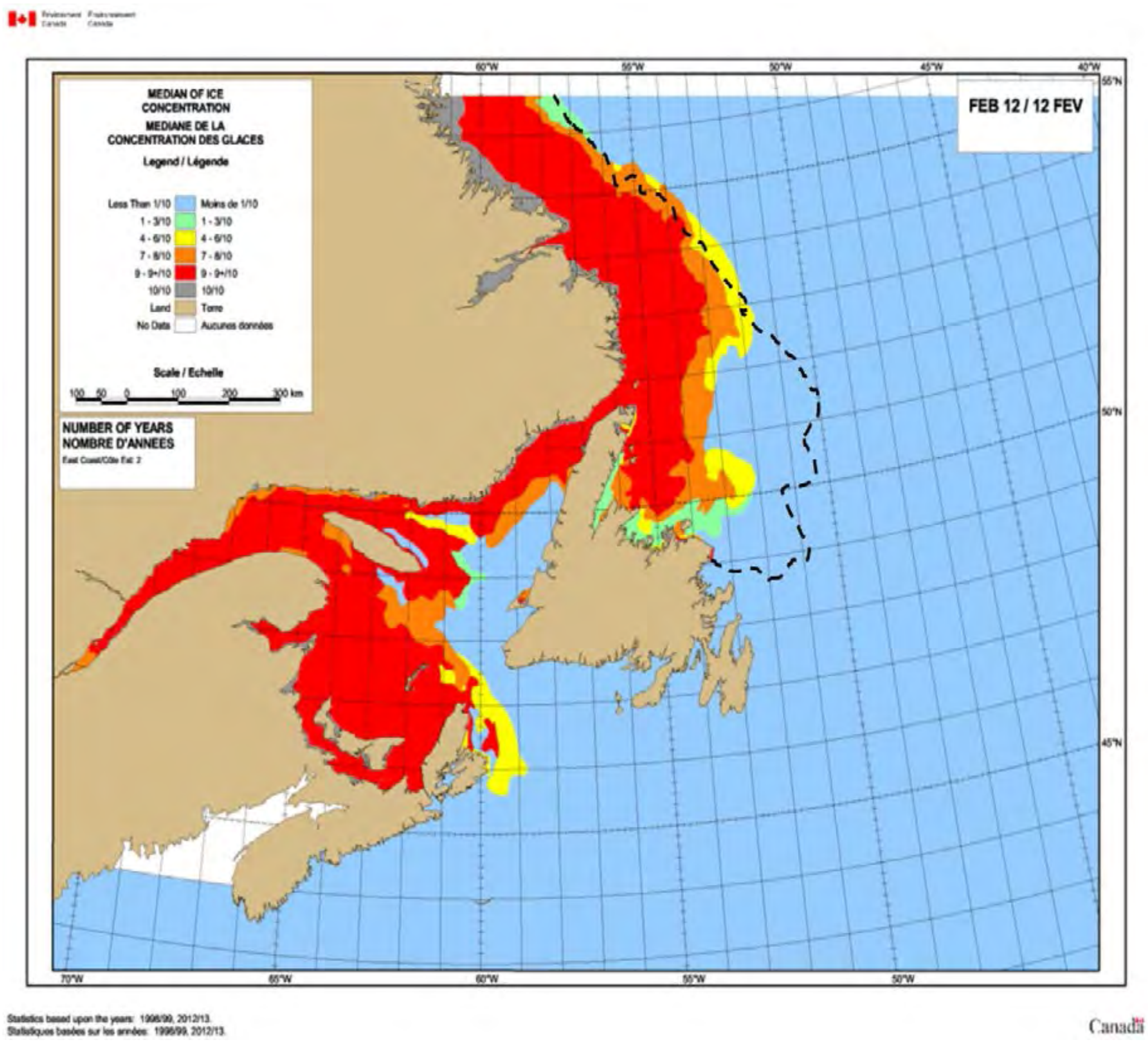

Figure 3. Comparison of CIS expected median sea ice concentration (shaded regions) for 12 February 2017, based on analog years. (1998/99, 2012/13) (CIS, 2016a) with actual approximate location (dashed line) of the 1-3/10 ice edge on 12 February 2017.

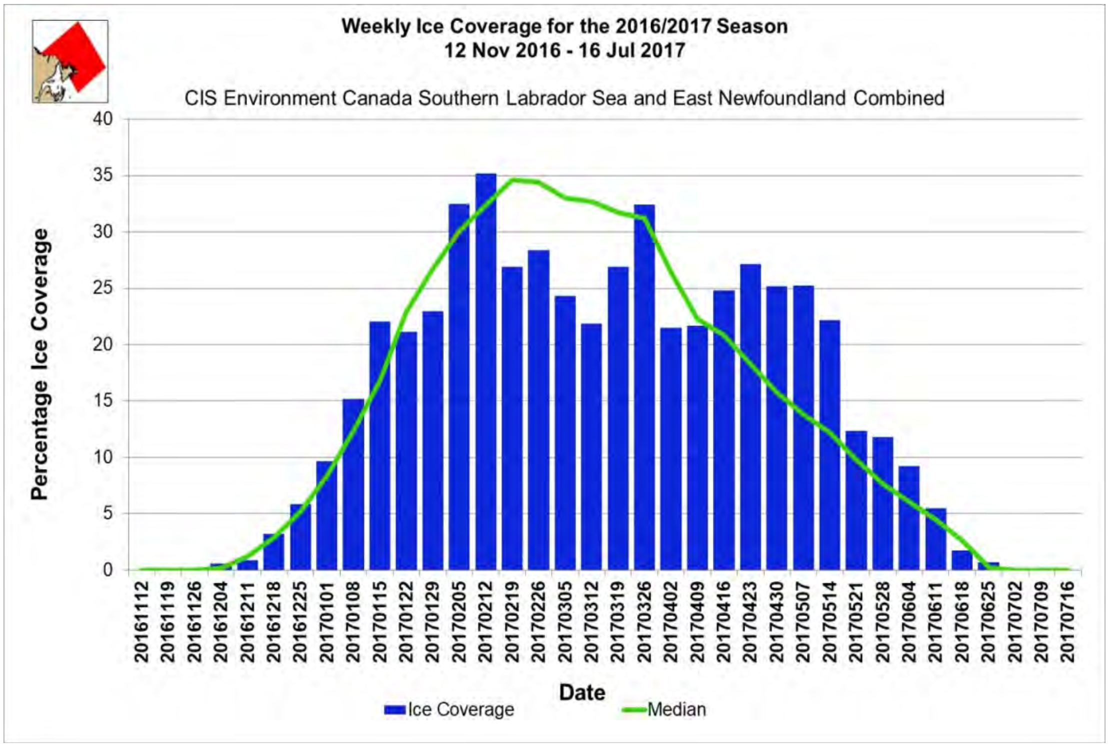

Figure 4. Weekly ice coverage for East Newfoundland and Southern Labrador Sea waters for 2016-2017. The percent coverage is relative to the area shaded in red in the upper left map of this figure (CIS, 2017a).

Labrador, the CIS forecast for diminished sea ice coverage held throughout the winter (**Figure 3**). Above average air temperatures kept sea ice growth to near median until mid-March. The sea ice concentration fluctuated around the median level until early April when it exceeded the median for the remainder of the year. Sea ice coverage throughout Newfoundland and Labrador from November 2016 through July 2017 is shown in **Figure 4.** However, powerful, hurricane-force storm systems in March caused sea ice destruction and a rapid contraction of sea ice toward Newfoundland. With the rapid retreat of sea ice from within the offshore branch of the Labrador Current, iceberg observations in the shipping lanes increased dramatically in late-March through early April. Persistent onshore winds from the northeast in April set the stage for particularly hazardous conditions for shipping – both with respect to the number of icebergs and the amount of sea ice surrounding the Avalon Peninsula. Air temperature anomalies significantly

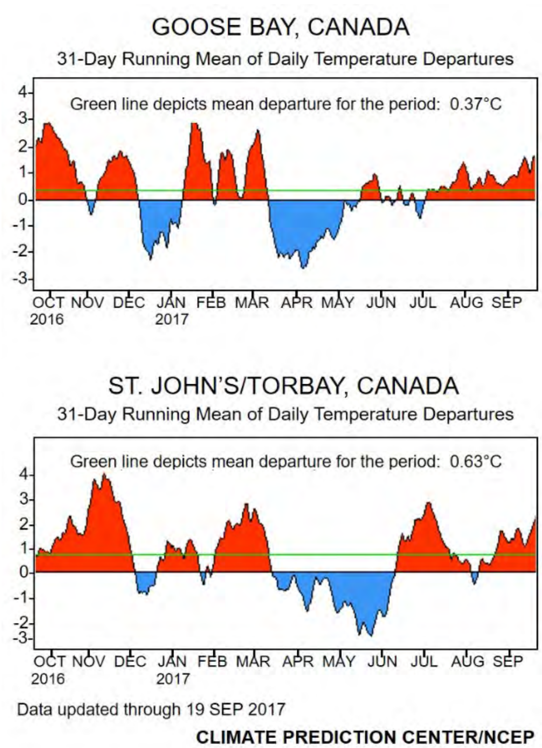

Figure 5. 31-day running mean of daily temperature departures for Goose Bay (top) and St. John's, Newfoundland (bottom) (NOAA/NWS, 2017a).

influenced sea ice growth and retreat across the OPAREA. **Figure 5** shows the daily air temperature departures from mean throughout the Ice Year at two key locations along the east coast of Canada: Goose Bay, Labrador (top panel) and St. John's, NL (bottom panel) (NOAA/NWS, 2017a). Below normal air temperatures in December and early January created sea ice growth that was close to the median concentration for Newfoundland and Labrador. Above normal air temperatures at both locations from January through mid-March (**Figure 5**), kept sea ice growth to below the median with exception of the last week of January and first week of February, due to strong northwesterly winds prior to these two weeks. Air temperatures at both locations reversed in mid-March with the arrival of the severe winter storms described earlier. Temperatures remained below normal from mid-March through mid-May in Goose Bay and Labrador. The timing of this cold air reversal coupled with the onshore winds experienced in April through May caused a significant delay in sea ice clearing until mid-June (CIS, 2017a). After June, air temperatures generally stayed above normal for the remainder of the Ice Year.

As described in prior IIP Annual Reports (e.g., IIP, 2016), the NAOI represents the dominant pattern of winter-time atmospheric variability in the North Atlantic, fluctuating between positive and negative phases. Generally, a positive phase of the NAOI is associated with offshore winds that supply cold air from Newfoundland and Labrador promoting seaward sea ice growth. Onshore winds, associated with a negative phase of the NAOI, inhibit seaward sea ice growth, leaving icebergs exposed to open waters and causing grounding events which limit iceberg movement toward the offshore branch of the Labrador Current.

Figure 6 shows the daily 500 millibar (mb)-based NAOI calculated from 04 December 2016 through 02 April 2017 (NOAA/NWS, 2017c). While the daily NAOI oscillated between negative and positive phases, the positive occurrences generally lasted longer and had greater magnitude than the negative events.

Mean station-based NAOIs are also calculated using the difference in normalized sea-level atmospheric pressure between Lisbon, Portugal and Stykkisholmu/ Reykjavik, Iceland (Hurrell, 1995). The winter-time, station-based NAOI for December through March each year provides a good indicator for sea ice growth conditions in the IIP OPAREA. In 2017, the NAOI was moderately positive at +1.47, supporting overall winter-time growth of sea ice in Newfoundland and Labrador. The southward drift of the sea ice edge, in turn, promoted the progression of icebergs toward 48°N by early March.

In contrast, the station-based NAOI for April through June was -1.4. This NAOI reversal from winter to spring was consistent with predominantly onshore winds observed in April and May. Persistent onshore flow caused westward drift and compression of sea ice toward Newfoundland.

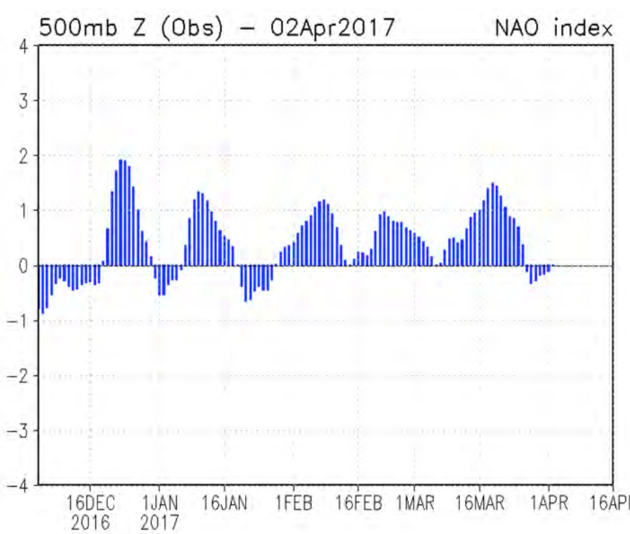

Figure 6. 500 mb NAOI for 04 December 2016 through 02 April 2017 (NOAA/NWS, 2017b).

Quarterly Environmental Summaries
October – December 2016

At the start of the Ice Year, CIS was responsible for setting the Iceberg Limit and distributing daily products. Four icebergs in the eastern Gulf of St. Lawrence and three within Notre Dame Bay established the Iceberg Limit at approximately 49°30'N on both sides of Newfoundland. Few icebergs were also scattered along the Labrador Coast up to 60°N. By 20 October, the Iceberg Limit receded north of the Strait of Belle Isle with only three icebergs remaining along the Labrador coast.

As projected by CIS, warmer than normal air temperatures along the East Coast of Canada kept sea ice growth in check during this period. Sea ice began forming in Lake Melville (near Goose Bay) during the last week of November. Ice continued to grow across Lake Melville and along the southern coast of Labrador throughout the remainder of November. As shown in **Figure 5**, colder than normal air temperatures in Goose Bay, and, to a lesser extent, in St. John's, promoted sea ice growth in the bays in the northern part of Newfoundland beginning in mid-December. By the end of December, sea ice advanced to 60 NM off of the southern Labrador coast and into the Strait of Belle Isle (CIS, 2017a).

By the end of December no icebergs had drifted south of 48°N, though several approaching this latitude caused the established limit to extend just south of 48°N to account for uncertainty in drift estimation.

January – March 2017

The cold air anomaly observed in Goose Bay in December abruptly reversed in early January, rising to nearly 3°C above normal (**Figure 5**). A similar reversal occurred in St. John's in late December. Warmer than normal air temperatures at both locations persisted until mid-March. With exception of two weeks in early February, air temperatures remained above normal throughout Newfoundland and Labrador until early-March. Sea ice grew to above the median in Newfoundland and Labrador during these two weeks but then decreased to below median with continued warmer than normal temperatures in late February. In early March, temperatures again reversed to below normal in both St. John's and in Goose Bay. Sea ice coverage grew to near median by the third week in March. The majority of the iceberg population remained confined within the sea ice edge until the end of March.

On 01 January 2017, CIS established the Western Iceberg Limit inside the Strait of Belle Isle and the Southern Iceberg Limit at 51°N as a result of a commercial aerial reconnaissance flight that detected two icebergs. Active aerial and satellite reconnaissance throughout February and March detected many icebergs – mostly north of 48°N and locked within the existing pack ice. Even with these sightings, identifying icebergs within sea ice by radar alone is challenging. Thus, reported sightings represented only a subset of the entire iceberg population.

Beginning on 11 March, a series of severe low pressure systems tracked through IIP's OPAREA. The first of these, a 964 mb low pressure system, tracked directly across Newfoundland bringing southerly winds with maximum wind gusts in excess of 84 knots (kts) that caused severe damage to structures on land. The storm dramatically weakened offshore sea ice and inhibited southward ice edge progression due to southerly winds. Another storm tracked further offshore and remained nearly stationary, centered near 45°W longitude (east of Flemish Cap) for more than two days. This system exposed the remaining pack ice and icebergs to unusually strong northwesterly winds that reached hurricane-force for more than 24 hours. The storm also caused the sea ice and the iceberg population to move southward rapidly over a very short time period. Four icebergs were reported outside of the Iceberg Limit as a result of these winds; the first by Fishing Vessel (F/V) RAN on 27 March and the other three by PAL Aerospace flights on 28 and 29 March.

Two more extreme systems on 31 March and 03 April brought strong northeasterly winds to the Grand Banks that forced and compacted the sea ice toward Newfoundland. Some smaller icebergs also drifted westward but many remained to the east of the Grand Banks allowing them to drift freely.

Prior to the arrival of these storm systems, only 37 icebergs had drifted south of 48°N. By 31 March, the count increased dramatically to 293 and continued to rise through the remainder of the year. IIP experienced a surge of international, national, and local media interest as a result of these iceberg conditions.

The unusual development of these events warrants additional discussion. **Figures 7** through **10** show the dramatic impact that the weather systems in late-March and early-April had on the sea ice and icebergs in the IIP OPAREA. This storm system brought persistent, hurricane-force, northwesterly winds on 27 and 28 March (**Figure 7**). **Figure 8** shows the geo-referenced CIS Sea Ice Concentration product with IIP's iceberg database overlaid for 26 March, prior to the storm, and on 29 March, after the system moved eastward and diminished in intensity. On 26 March (left panel of **Figure 8**), both the sea ice edge and the entire iceberg population were positioned north of 48°N. These conditions were consistent with IIP's observations during reconnaissance flight on the previous day. On 29 March 2017 (right panel of **Figure 8**) the iceberg population in this area rapidly drifted southward in the Labrador Current and ahead of the sea ice edge. Many icebergs drifted south of 48°N with one moving south of 46°N. Actual iceberg drift exceeded IIP's model predictions and ultimately resulted in four icebergs being located outside of the Southern Iceberg Limit.

On 31 March and 01 April, another intense system tracked through the IIP OPAREA (**Figure 9**). This storm moved eastward south of Newfoundland bringing northeasterly winds causing the sea ice to move westward towards Newfoundland. Another strong low-pressure system followed a similar trajectory bringing more northeasterly winds to further compress the sea ice around Newfoundland. **Figure 10** shows the sea ice and iceberg conditions on 01 and 04 April. On 01 April (left panel), the iceberg population remained in close proximity with the sea ice. However, by 04 April after these two storm systems passed through the area, the sea ice contracted dramatically around the Avalon Peninsula and bays of Newfoundland. Many smaller icebergs followed the sea ice with relatively few remaining offshore in the Labrador Current. A dramatic increase in the number of icebergs is also evident in **Figure 10.** These extreme weather events accelerated the drift of icebergs, previously undetected within the pack ice, into open water where they were readily detected by intensified reconnaissance during this time period. Further, positive identification of icebergs within the retreating and deteriorating sea ice likely contributed to the overall increase.

April - June 2017

The cold air temperature anomaly that began in mid-March continued until mid-May in Goose Bay and until mid-June in St. John's. The sea ice edge reached its southernmost extent on 01 April 2017. Predominantly onshore flow during April and May (**Figure 11**), caused sea ice to compress along the coast and in the bays of Newfoundland.

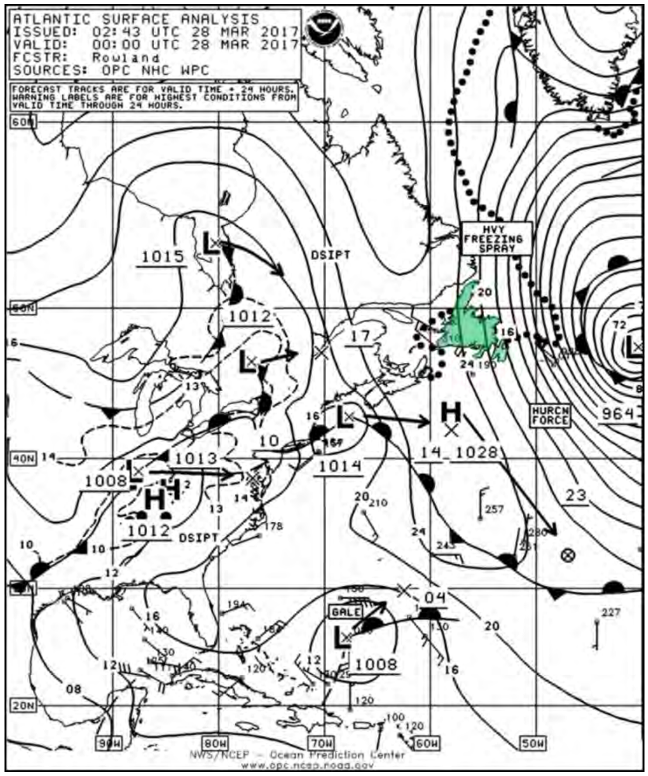

Figure 7. Atlantic Surface Analysis for 0000UTC on 28 March with Newfoundland shaded in green for orientation (NOAA/NWS, 2017c).

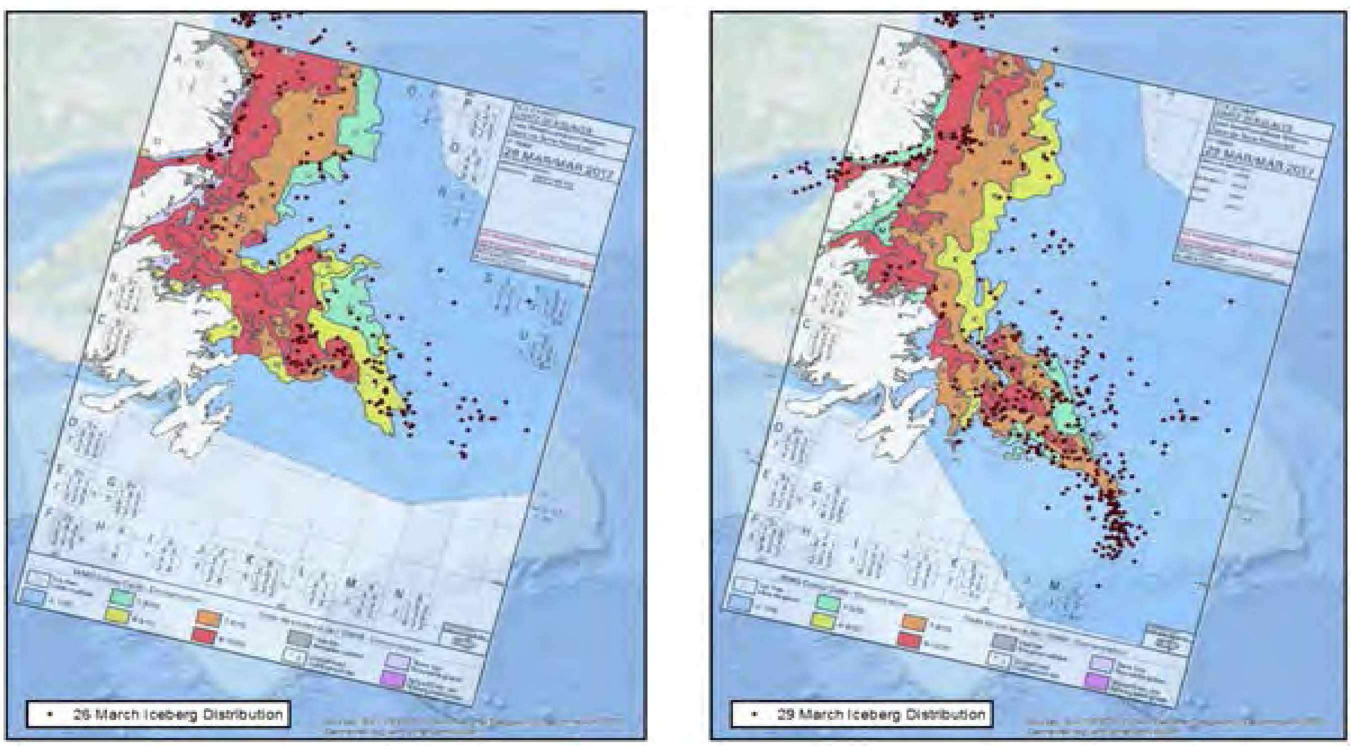

Figure 8. CIS Sea Ice Concentration with IIP Iceberg Distribution for 26 (left) and 29 (right) March 2017 (CIS, 2017d)

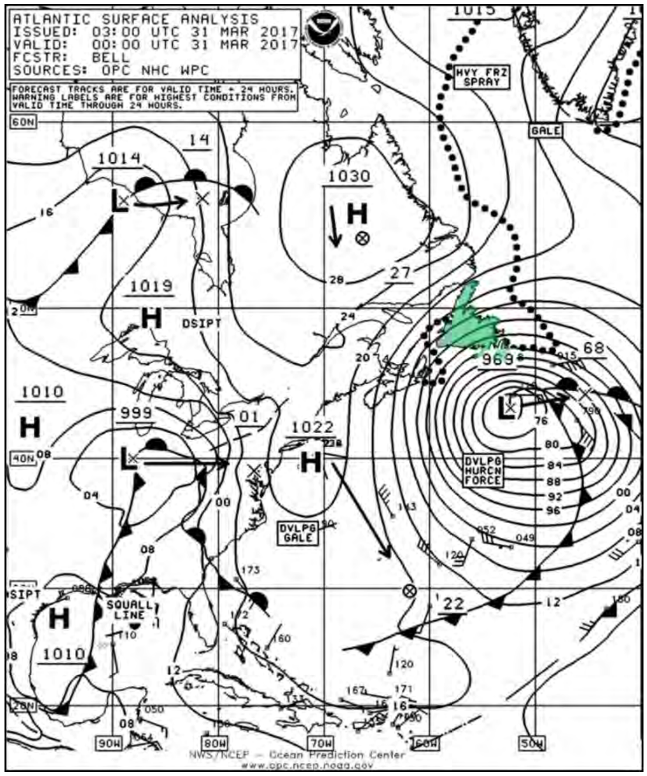

Figure 9. **Atlantic Surface Analysis for 0000UTC on 31 March with Newfoundland shaded in green for orientation (NOAA/NWS, 2017c).**

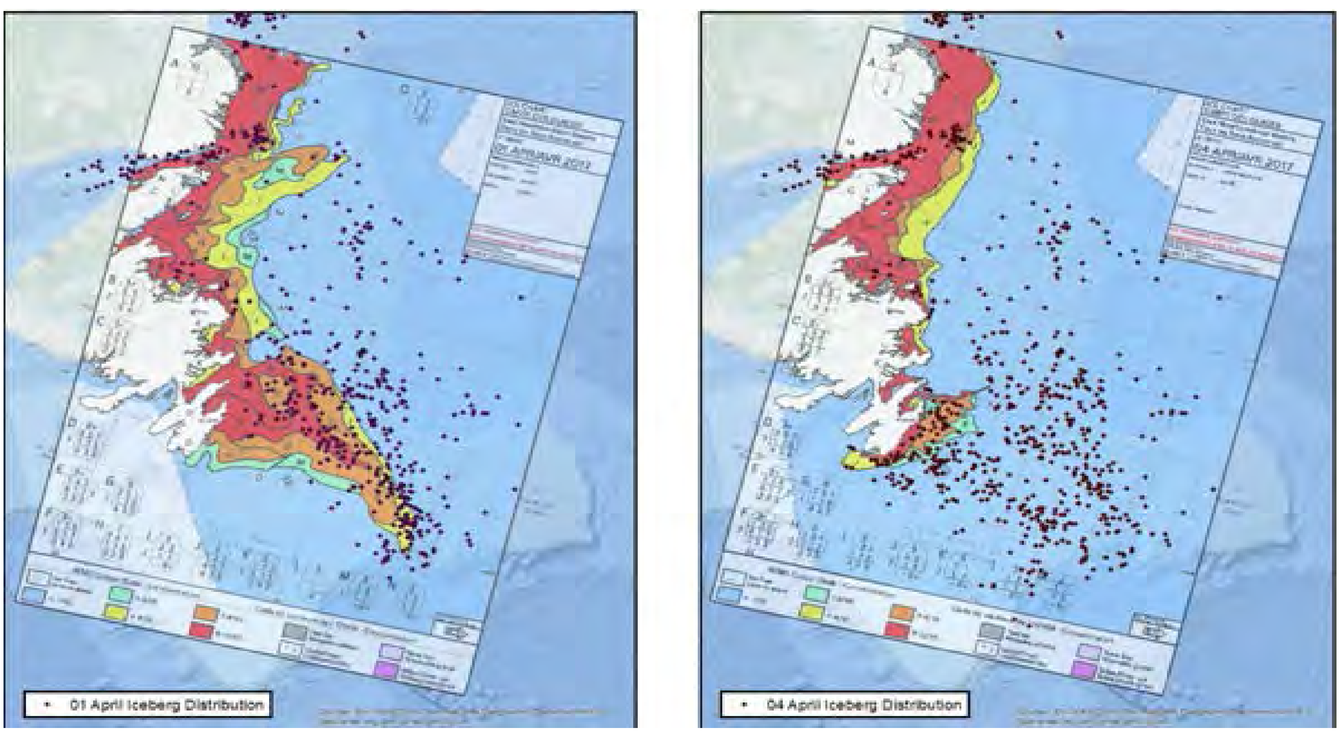

Figure 10. CIS Sea Ice Concentration with IIP Iceberg Distribution for 01 (left) and 04 (right) April 2017 (CIS, 2017d).

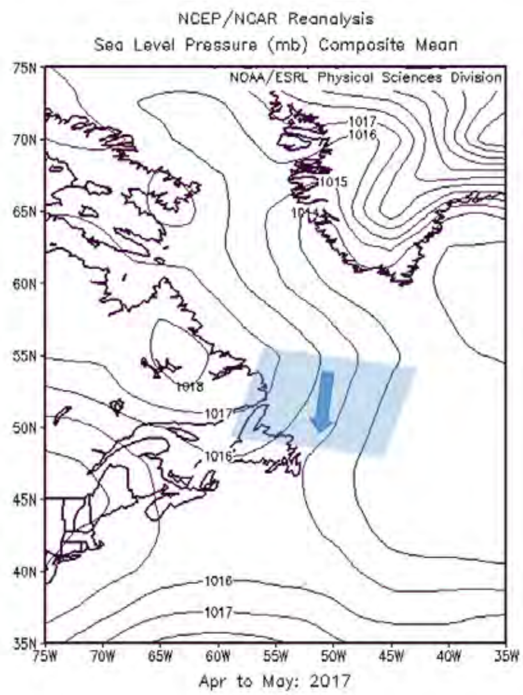

Figure 11. Composite Mean Sea Level Pressure for April to May 2017. The blue arrow (annotated by IIP) indicates approximate wind direction over the indicated area (blue shading) for the time period (NOAA/ESRL, 2017).

Figure 12 is the CIS sea ice concentration departure from normal for 08 May 2017. Blue shades indicate higher than normal concentration along the Avalon Peninsula and Labrador Coast. Many icebergs were also forced towards the Avalon Peninsula and remained in this area through June. As a result, the Iceberg Limit exceeded the extreme historical location southwest of Newfoundland. Of note, PAL Aerospace dedicated considerable effort to assess the icebergs and sea ice coverage in Trinity Bay, Newfoundland, to support the towing of the Hebron oil platform offshore. Ice conditions in this area delayed the scheduled tow for nearly a month until early June.

Sea ice first began to clear from the Strait of Belle Isle around mid-June and during the third week of June along the northeast Newfoundland coast. The retreat of sea ice happened around two months later than the climatological median due to the persistent

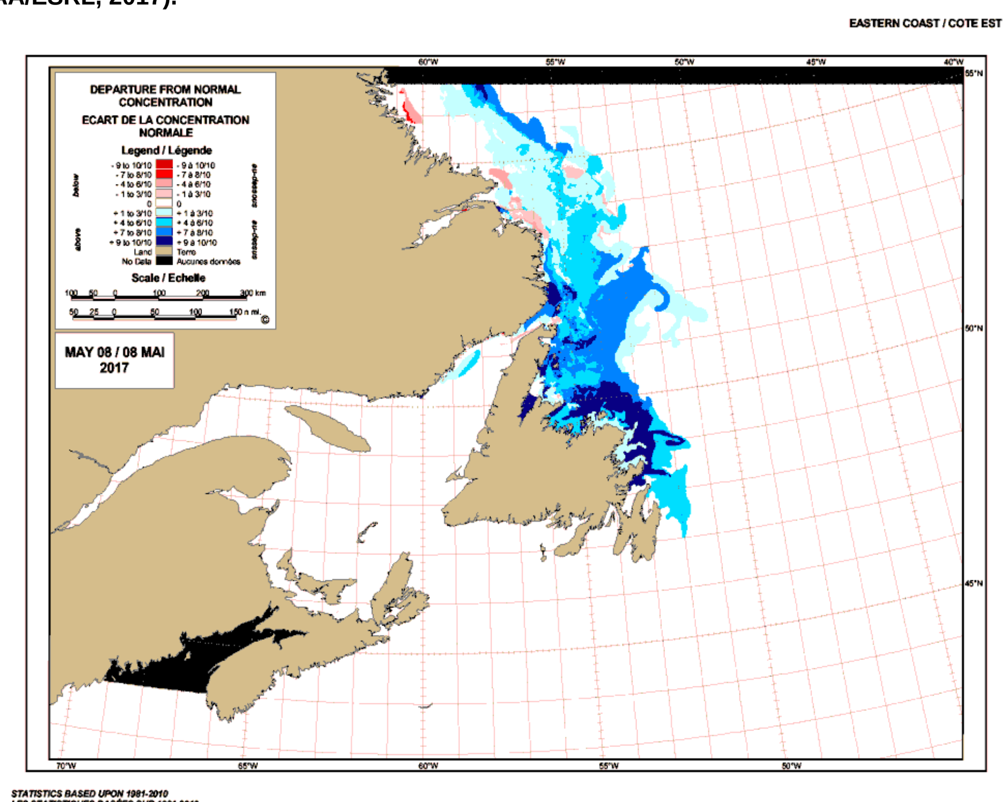

Figure 12. Sea ice departure from normal concentration for 08 May 2017 (CIS, 2017b).

onshore flow experienced during the spring (CIS, 2017a). Icebergs remained a hazard to shipping particularly around Newfoundland through June. By the end of June, 981 icebergs drifted or were sighted south of 48°N.

July - September 2017

Air temperatures in Goose Bay and St. John's remained above normal for the remainder of the Ice Year. By early July, only a small remnant of sea ice remained along the Labrador Coast north of 55°N latitude. Few icebergs lingered around the Avalon Peninsula. Many icebergs were still present in the Gulf of St. Lawrence and Strait of Belle Isle holding the Western Iceberg Limit out past 60°W longitude throughout July.

Isolated icebergs near the Avalon Peninsula and many in Notre Dame Bay and the Gulf of St. Lawrence remained through August. Several icebergs remained along the 1,000-meters (m) contour near 51°N and continued to drift southward. The Iceberg Limit receded to the north of 48°N on 27 September and remained so for the remainder of the Ice Year.

In summary, **Figure 13** graphically shows the number of icebergs estimated to have drifted south of 48°N by month for the 2017 Ice Year. The monthly average was calculated using 116 years (1900 through 2016) of IIP records and is plotted as a solid red line for comparison. Note the significant number of icebergs that crossed 48°N in April compared to the 1900-2016 average peak that occurs in May. A summary of extreme iceberg positions, both sighted and drifted by modeling, along with the sighting source is presented in **Table 1**.

Oceanographic Operations

Dynamic oceanographic conditions in IIP's OPAREA demands careful study of the ocean currents, in particular, the offshore branch of the Labrador Current and its interaction with the North Atlantic Current near the Tail of the Grand Banks. IIP used seven drifting buoys on and near the Grand Banks of Newfoundland to collect near real-time ocean current information. IIP used data from these buoys to refine the historical ocean currents database within BAPS and improve the accuracy of the model-calculated drift for each iceberg. IIP drifting buoys are based on the Surface Velocity Program (SVP) design. The buoys, with "holey sock" drogues centered at 50 m in depth, were deployed in the offshore branch of the Labrador Current. This current is responsible for transporting icebergs

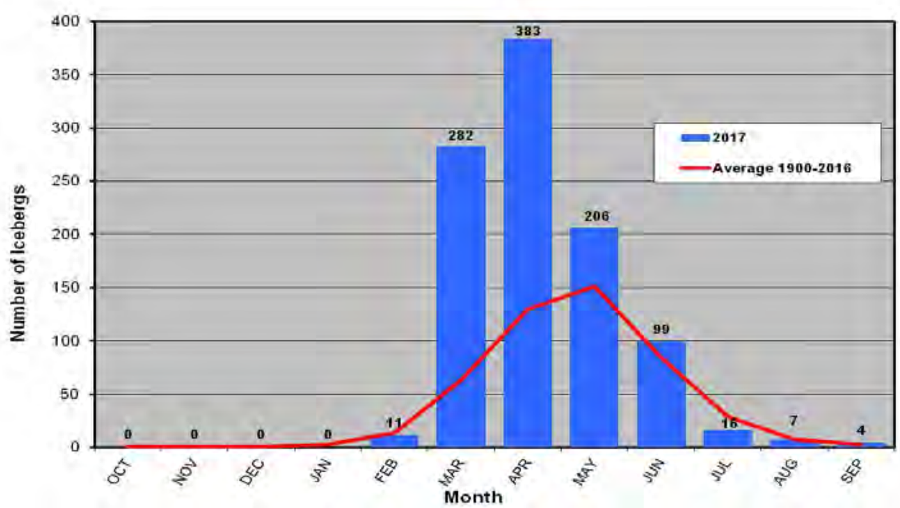

Figure 13. Estimated number of icebergs passing south of 48°N by Month (1008 total for 2017).

Extreme Icebergs	Sighted				Drifted			
	Source	Date	Latitude	Longitude	Source	Date	Latitude	Longitude
Southern	IIP HC-130J	06-Apr-17	43-14.0N	49-04.0W	IIP HC-130J	16-Apr-17	41-12.2N	48-24.2W
Eastern	Vessel	29-May-17	46-33.0N	43-45.4W	Vessel	04-Jun-17	46-40.0N	41-58.0W
Western	PAL Aircraft	15-Jun-17	49-36.0N	61-44.0W	PAL Aircraft	15-Jun-17	49-36.0N	61-44.0W

Table 1. 2017 Extreme sighted and drifted (modeled) iceberg positions by original sighting source and date.

southward along the edge of the continental shelf and into the shipping lanes.

IIP used reconnaissance aircraft and Canadian Coast Guard (CCG) ships to deploy the drifting buoys. Air deployments were conducted during regular reconnaissance patrols using an air-drop package prepared by IIP and ASEC personnel. Air deployments were conducted offshore in regions outside of the normal range of the CCG ships. Ship deployments were conducted on or near the Grand Banks through a cooperative arrangement with CCG ships operating out of St. John's, NL.

In 2017, IIP successfully air-deployed six 50 m, SVP drifting buoys (**Figure 14**). One 50m buoy was successfully deployed by the CCG. All SVP buoys used GPS-based positioning that were processed under the Iridium satellite communication network. SVP buoy data were processed by CLS America for the 2017 season. **Figure 15** shows all of the buoy deployment locations and tracks for the 2017 season. The green stars represent the deployment location for each buoy.

The variation in the buoy tracks demonstrates the significant temporal and geographic variability in ocean currents within IIP's OPAREA, solidifying the importance of the real time in-situ current measurements provided by the SVP buoy program.

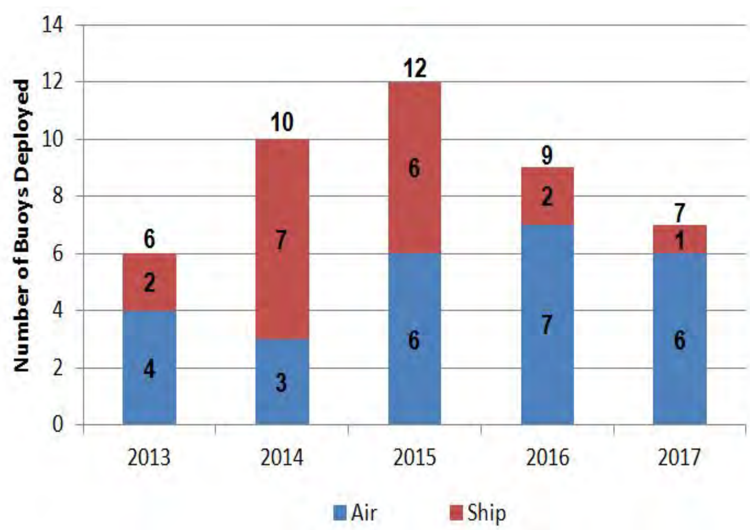

Figure 14. IIP SVP drifting buoy deployments by platform for 2013 through 2017.

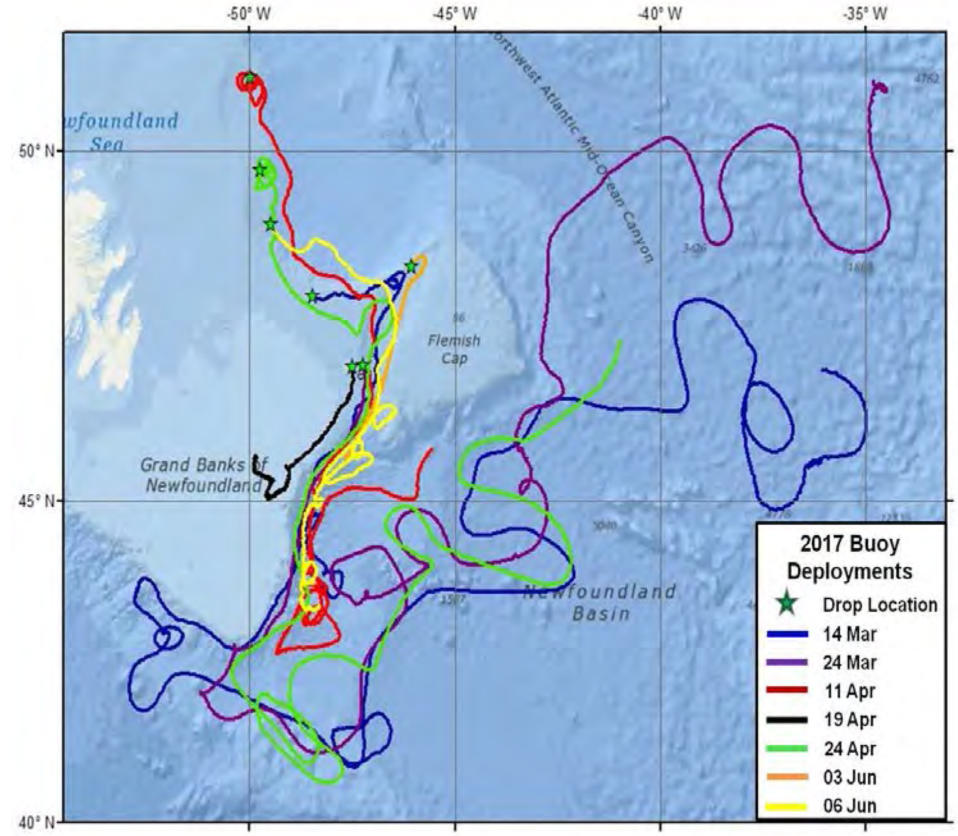

Figure 15. IIP SVP driving buoy composite tracks for 2017 deployments.

Operations Center Summary

The IIP OPCEN is the hub of IIP's information processing and dissemination. IIP OPCEN watchstanders receive iceberg reports from a variety of sources, process the information, and create daily iceberg warning products that are distributed to mariners. Iceberg reports are received from IRD flights, commercial reconnaissance flights, Synthetic Aperture Radar (SAR) satellite imagery, and vessel sighting reports. After these reports are processed, icebergs are added to the IIP's iceberg database and run through the drift and deterioration model on BAPS. Iceberg limits are then set to contain the modeled iceberg positions and warning products are created and distributed to mariners via multiple methods.

Products and Broadcasts

IIP and CIS partner to create and distribute two versions of the Iceberg Limit daily. IIP produces products "in season" when icebergs typically threaten the transatlantic shipping lanes, which spanned from 24 January to 30 August 2017. During the remainder of the 2017 Ice Year, termed "out of season", CIS created products as icebergs typically retreat north along the Canadian coast.

The NAIS-10 Iceberg Bulletin, a text product, describes the latitude and longitude waypoints of the Iceberg Limit and sea ice limits. A graphical version, the NAIS-65 Iceberg Chart, shows the forecasted Iceberg Limit and estimated concentrations of icebergs in a 1° x 1° latitude/longitude gridded cell. Examples of the NAIS-65 Iceberg Charts can be found in a later section of this report. Both products include information regarding the most recent reconnaissance including the date, type, and coverage area. These two products are released between 1830Z and 2130Z and are valid for 0000Z the following day. During the 2017 Ice Season, all broadcast schedules were met with 100% of iceberg warning products released on time.

IIP distributes the NAIS iceberg warning products to the public in a variety of methods. The NAIS-10 Iceberg Bulletin is broadcast over an automated satellite system (SafetyNET), Navigational telex (NAVTEX), Simplex Teletype Over Radio (SITOR), and posted online. The NAIS-65 Iceberg Chart is broadcast over radio facsimile (Radiofax) and posted online. Both products are posted to IIPs website: www.navcen.uscg.gov/?pageName=iipCharts. Additionally, the NAIS-65 iceberg chart is available on the National Weather Service (NWS) Marine Forecast website and National Oceanographic and Atmospheric Administration (NOAA) Ocean Prediction Center (OPC) website: http://tgftp.nws.noaa.gov/fax/marsh.shtml and www.opc.ncep.noaa.gov/Atl_tab.shtml. Also, keyhole markup language (KML) files of the iceberg forecast limits and sea ice limits are available on the IIP website for use with any web-based mapping software. Finally, the daily Iceberg Limit is a displayable layer within NOAA's Arctic Environmental Response Management Application (ERMA) mapping tool: https://response.restoration.noaa.gov/maps-and-spatial-data/environmental-response-management-application-erma/arctic-erma.html.

Product Changes for 2017

Each year IIP, in conjunction with CIS and the Danish Meteorological Institute (DMI), reviews products, procedures, and processes to improve content, delivery, and value to the mariner. For 2017, the estimated sea ice limits around Greenland were included in the iceberg products. The

Greenland sea ice extent is monitored by DMI, reported to CIS for inclusion in the sea ice limits, and incorporated into the daily iceberg warning products. Future efforts may include incorporating DMI iceberg data around Greenland into BAPS and the NAIS product.

The Canadian Ice Service developed an update to BAPS that automated iceberg chart creation with drop down options to select the chart view and information about the most recent reconnaissance including: type, location, date, and time. Automating the chart generation process increased the efficiency and consistency of product generation while also supporting the 2016 addition of reconnaissance information.

Additionally, during the 2017 ice season, IIP began to distribute a weekly Iceberg Outlook. This weekly forecast provides information regarding the location and general number of icebergs expected over the next week. The outlook is based on climatological records, environmental trends, and model output. The weekly outlook was posted to the IIP and OPC websites.

IIP Protocol for Icebergs Reported Outside of the Iceberg Limit

Icebergs reported outside the published NAIS limit pose a particularly hazardous condition for mariners. As such, if an iceberg or radar target is reported outside the published NAIS iceberg limit, OPCEN watchstanders take prompt actions to ensure timely notification to the shipping community and the accuracy of the NAIS products. This action includes examining the reconnaissance schedule, broadcasting safety information, revising warning products, and running the drift and deterioration model to identify adjustments to improve product accuracy.

Upon notification of an iceberg or radar target outside the limit, watchstanders notify the CCG Maritime Communication and Traffic Service (MCTS) Port-aux-Basque. In turn, MCTS issues a Notice to Shipping (NOTSHIP). The NOTSHIP immediately relays critical iceberg information to the transatlantic shipping community while IIP watchstanders revise products accordingly. The NOTSHIP is broadcast via NAVTEX and automatically forwarded to the U.S. National Geospatial-Intelligence Agency (NGA). NGA then broadcasts the message as a Navigational Area (NAVAREA) IV warning message over SafetyNET and posts it to their website. NAVAREA IV is one of 21 Navigation Areas designated by the World Wide Navigation Warning System (WWNWS). The United States is the NAVAREA coordinator for NAVAREA IV, which covers the western part of the North Atlantic Ocean eastward of the North American coast to 35ºW, from 7ºN to 67ºN and includes all of IIP's OPAREA.

If the report of the iceberg or radar target outside the limit is received by IIP after products are distributed, but still during watch hours, products will be immediately revised and released. For reports that reach IIP after watch hours, products will be revised and released no later than 1400Z the following morning.

Early in the Ice Year, there were two instances of icebergs or radar targets reported outside the published limit in December 2016. Over the in-season period there were six reports of icebergs or radar targets outside the published limit. On the last day of the Ice Year, 30 September 2017, there was an iceberg reported south of the published limit. While the six in-season icebergs reported outside the published limit were only 0.59% of the 1,008 icebergs reported south of 48ºN, they represent a potentially dangerous situation for vessels following the published iceberg limits.

Therefore, it remains critical for IIP to document and learn from each case to improve execution of the IIP mission in the future.

In-Season Icebergs and Radar Targets Outside the Iceberg Limit

1. On 12 February 2017, a Canadian Government-funded PAL Aerospace flight detected an iceberg, both visually and via SAR, approximately six miles from the published limit. Products were revised and a NOTSHIP was issued. This report was received before IIP began conducting aerial reconnaissance for the 2017 Ice Season.

The next four reports of icebergs or radar targets outside the limits can be attributed to two extremely strong low pressure systems in late March and early April. As described in the Ice and Environmental Conditions Section, the two low pressure systems affected icebergs and sea ice in the IIP OPAREA. The southward iceberg drift exceeding the published limit during the period of 27 to 29 March was attributed to the hurricane-force northwesterly winds created by this low pressure system. The second strong low pressure system remained further to the south and caused icebergs to drift outside of the southwestern Iceberg Limit on 05 April.

2. On 27 March 2017, F/V RAN notified IIP via e-mail of an iceberg outside the limit located at 47º35'N, 45º25'W. IIP notified MCTS and a NOTSHIP was issued. Due to the time of the report, the products were not revised; however, the limit was extended and incorporated in the next day's products. This iceberg was not detected by the IRD searching the same area two days earlier on 25 March **(Figure 16)**. However, that iceberg flight was prior to the severe low pressure system that moved into the area.

The iceberg outside the limit on 27 March provided an opportunity for comparison of the two different drift and deterioration models (the IIP and NAIS model) used within BAPS. The IIP model has been used since 1983, as the primary drift and deterioration model for the creation of daily iceberg limit products. The NAIS model was developed by CIS in 2007 and it contains a different drift and deterioration algorithm along with different environmental inputs. Further discussion of the two models can be found in Appendix B of IIP, 2016. The arrows shown in **Figure 17** represent the approximate relative trajectories predicted by each model leading to the 27 March sighting. The NAIS model drift (red arrow) better captured the drift direction of the iceberg. Meanwhile the IIP model (blue tracks) did not capture the set or drift of the iceberg correctly. The sighted iceberg location falls somewhere between the two models drift results and highlights a key limitation within BAPS. In its current configuration, BAPS cannot leverage results from multiple models or represent uncertainty in environmental parameters through ensemble modeling. This capability may have better represented iceberg drift and allowed IIP to produce a more accurate limit.

3. On 28 March 2017, an Industry-funded flight by PAL Aerospace reported two icebergs just south of the published limit **(Figure 17)**. They were detected both visually and by radar. The MCTS was notified and a NOTSHIP was issued. Products were not revised due to the time of the report.
4. On 29 March 2017, a CIS-funded iceberg reconnaissance flight by PAL Aerospace reported an iceberg just south of the published limit **(Figure 18)**. IIP notified MCTS and a NOTSHIP was issued. An IRD conducted an iceberg reconnaissance flight over the area the

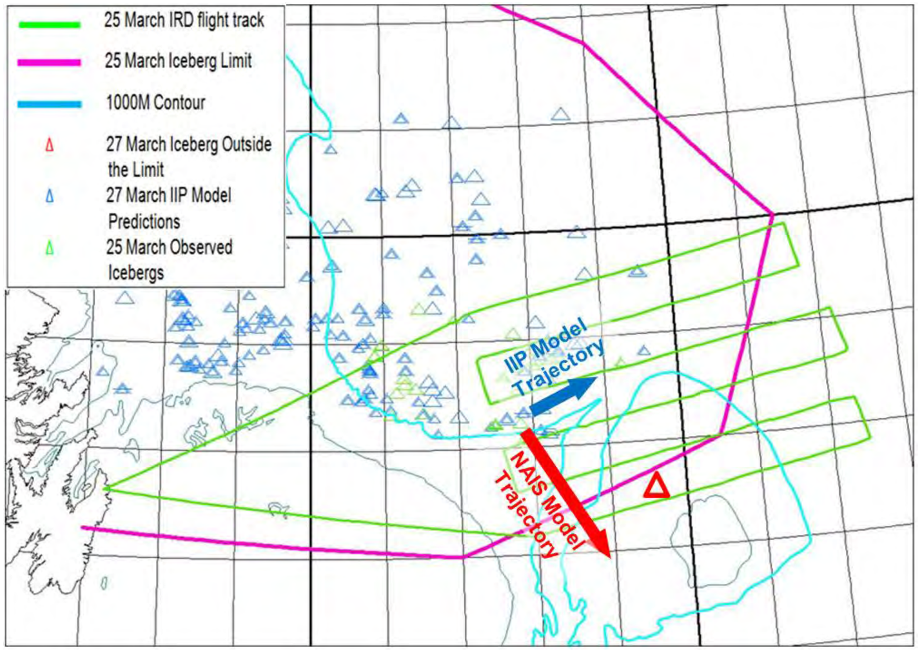

Figure 16. 27 March 2017. The IRD flight track shows the flight conducted on 25 March 2017 during which icebergs were not observed in the vicinity of the southern portion of the limit. Two days later, on 27 March 2017, an F/V reported an iceberg outside the limit. As a result, the limit was extended for the next day's products.

same day and detected a ship on AIS in the exact position the iceberg was reported. The iceberg was not incorporated into products.

5. On 05 April 2017, a Canadian Government-funded PAL Aerospace flight reported three icebergs outside the southwestern limit **(Figure 19)**. A NOTSHIP was issued by MCTS and IIP revised the daily chart and bulletin. An IIP IRD flight flew over the area where the icebergs were reported while en-route from Groton, CT to St. John's, NL, but did not observe the icebergs as they were in transit, not reconnaissance, mode.
6. On 29 May 2017, Placentia Bay Vessel Traffic Service relayed an iceberg report from Motor Vessel (M/V) LOUIS of a cluster of three icebergs approximately 90 NM east of the published limit. IIP notified MCTS and a NOTSHIP was issued. IIP revised the daily chart and bulletin. These icebergs were located southeast of Flemish Cap and either drifted northward then east of Flemish Cap or were transported in an eastward drifting jet of the Labrador Current south of Flemish Pass. Prior to this report there was a three week period without IIP IRD flights because of a cancelled IRD. Although most of the lost IIP flight reconnaissance hours were made up by PAL Aerospace flight reconnaissance, the location of these icebergs were well outside their flight range. It was possible that the IRD cancellation contributed to the non-detection of the icebergs.

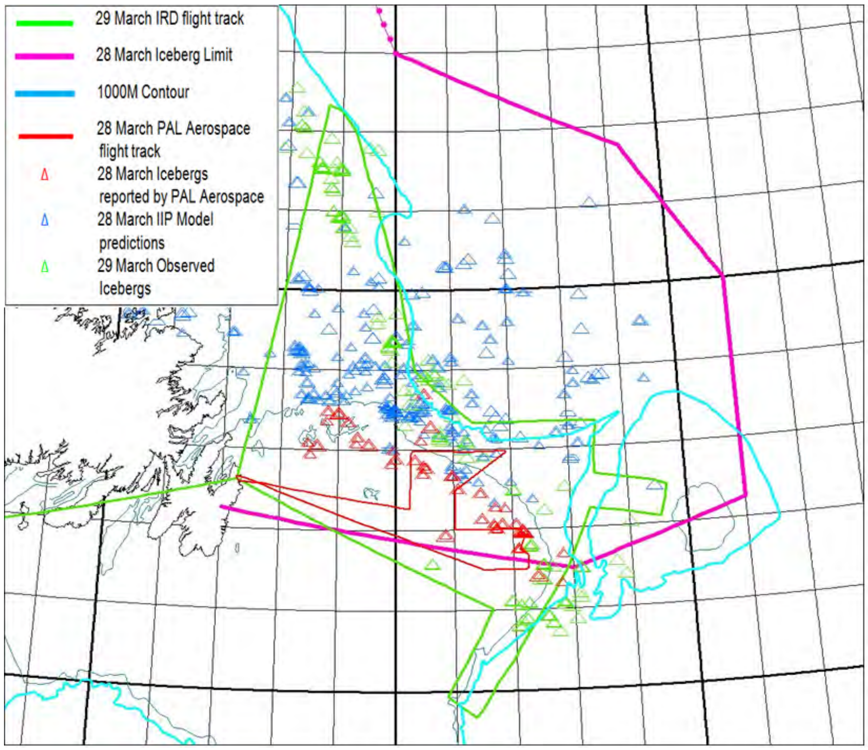

Figure 17. 28 March 2017. A PAL Aerospace flight reported 2 icebergs south of the limit (in red). The following day, an IRD flight flew over the area and detected an increased number of icebergs in that region since the previous IRD reconnaissance.

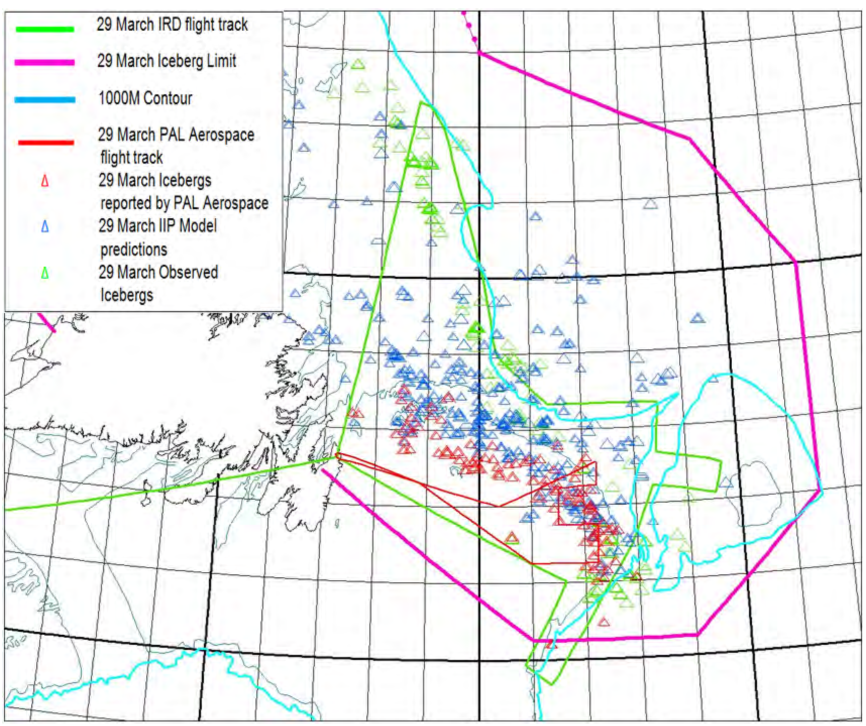

Figure 18. 29 March 2017. A PAL Aerospace flight reported an iceberg barely south of the limit, detected by radar with visual confirmation. IRD flight went over the area approximately 4 hours later and detected a ship on Automatic Identification System (AIS) in the exact position as the iceberg. IRD reported cloud-covered conditions throughout the flight and targets were observed by radar only. The iceberg was not incorporated into the model.

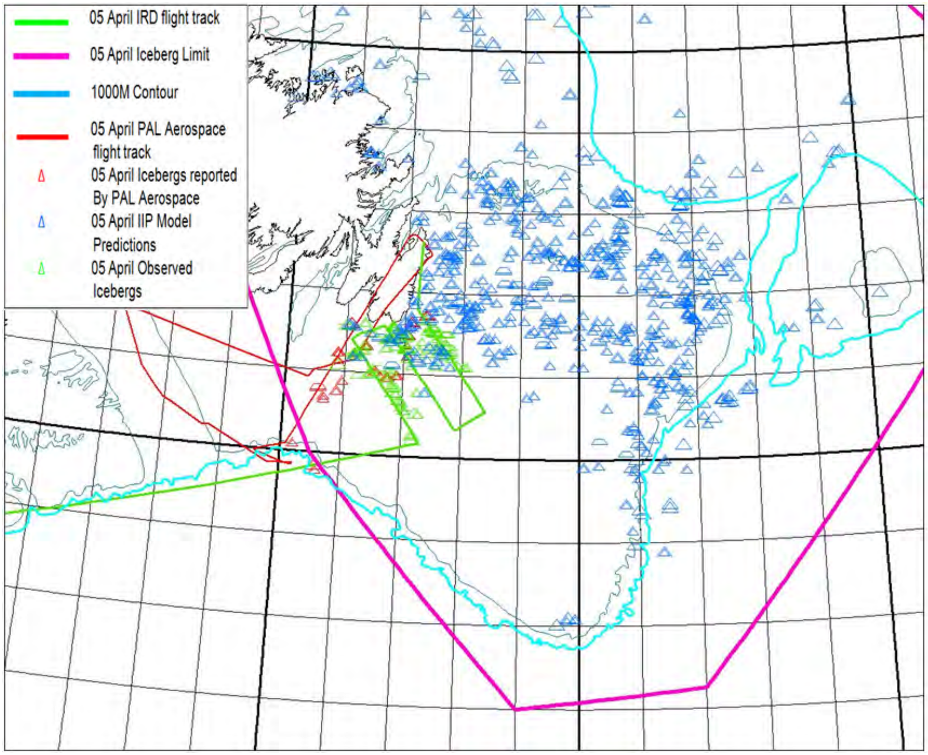

Figure 19. 05 April 2017. Three icebergs were reported west of the published limit by a PAL Aerospace flight. The IRD flight track (in green) shows that an IRD flight flew over the area en-route from Groton, CT to St. John's, NL after receiving the report, but began their patrol closer to St. John's than the reported iceberg positions. The icebergs were incorporated into the model. IRD reported good visibility (8 to 12 NM), but heightened sea state (1 to 3 half meters).

Out of Season Icebergs and Radar Targets outside the Iceberg Limit

1. On 03 December 2016, the M/V QAMUTIK reported an iceberg in the Strait of Belle Isle located in position 51º07'N, 57º23'W. The vessel observed the iceberg both visually and by radar. CIS added the iceberg to the iceberg database, extended the existing Iceberg Limit and created a Western Iceberg Limit. The notification was received prior to issuing products, so no revisions were necessary.

2. On 13 December 2016, a PAL Aerospace iceberg reconnaissance flight, funded by CIS, sighted an iceberg just south of the published limit. MCTS was notified and a NOTSHIP was issued. Due to the time of day revised products were not released, but the following day's limits were updated.

3. On 30 September 2017, an iceberg was reported approximately 120 NM south of the published limit by a PAL Aerospace flight funded by the Canadian Government. MCTS was notified and a NOTSHIP was issued. CIS updated the iceberg limits and issued revised products.

Iceberg Reports

The International Ice Patrol OPCEN received reports of icebergs from a variety of sources including IRD flights, PAL Aerospace flights, ship reports, and satellite reconnaissance. Collecting and processing iceberg reports from the wide array of sources augments IIP's reconnaissance mission. An important factor aiding IIP's successful safety record are the reports received from the maritime community transiting through IIP's OPAREA. A list of the individual ships that made voluntary iceberg reports during the 2017 Ice Season is compiled in **Appendix A**. Since 2005, IIP has awarded the Carpathia Award, to the vessel making the most iceberg sighting reports. Canadian Coast Guard Ship (CCGS) George R. Pearkes earned the 2017 Carpathia Award.

To better capture iceberg sightings by the CCG, IIP tailored a reporting tool streamlining the process. CCG ships filled a form in plain language (i.e. size, shape, position, and sighting method) and e-mailed the document to IIP's OPCEN. IIP then incorporated these reports into the iceberg model. The straightforward spreadsheet ensured complete iceberg reports were made and streamlined data entry for IIP watchstanders. The reporting tool greatly increased the frequency and thoroughness of CCG reports, validating and providing data in critical areas not otherwise covered. A similar tool is being developed for commercial reporting.

Overall, during the in-season period from 24 January 2017 to 30 August 2017, IIP received, analyzed, and processed 626 standard iceberg messages (SIMs), nearly a 60% increase over the 2016 season. **Figure 20** provides a ten-year summary that shows the number of SIMs received compared with the number of icebergs that drifted south of 48°N for each year. The first columns of **Figure 21** and **Table 2** show the distribution of these iceberg messages by reporting source.

The increase in total iceberg messages received is attributed to IIP's incorporation of daily satellite iceberg reconnaissance. Additionally, IIP received more iceberg messages from commercially sponsored PAL Aerospace flights than over the previous two years. This increase resulted from a surge in reconnaissance immediately following the late March and early April severe low pressure weather systems.

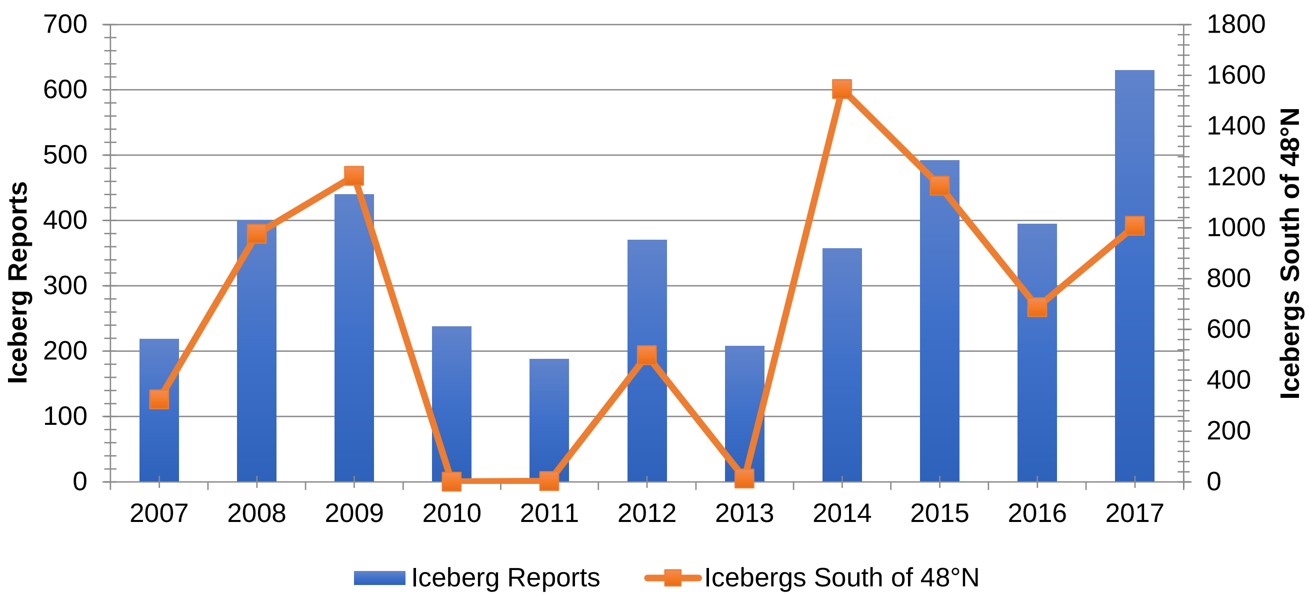

Figure 20. Total Iceberg reports received by IIP each year relative to Ice Season Severity 2007-2017, represented by the number of icebergs crossing south of 48°N.

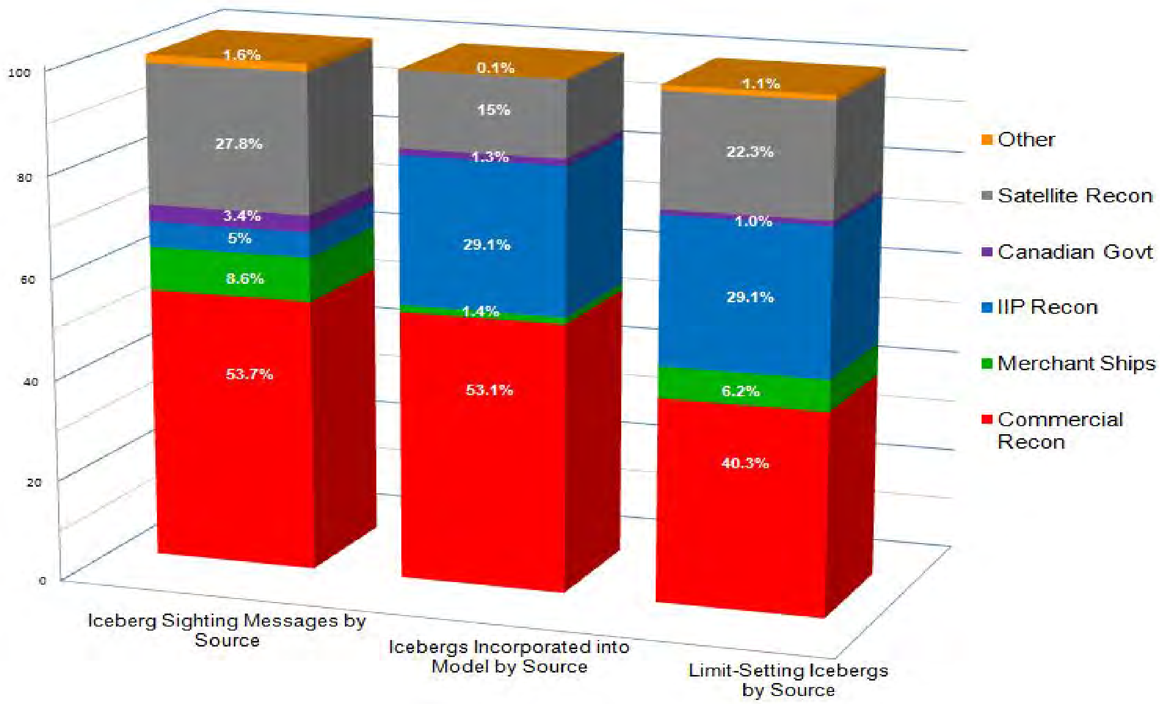

Figure 21. Percentages of iceberg sighting messages, icebergs and growlers incorporated into the iceberg database, and limit-setting icebergs by reporting source in 2017.

Reporting Source	Iceberg Sighting Messages	Icebergs Incorporated into Model	Average Icebergs Per Message	Limit-Setting Icebergs
Other	10	10	1	10
Satellite Recon	174	1799	10	204
Canadian Government	21	159	8	9
IIP Recon	31	3485	112	266
Merchant Ships	54	164	3	57
Commercial Recon	336	6360	19	368
Total	626	11977	20	914

Table 2. Numbers of iceberg sighting messages, icebergs and growlers incorporated into the model, average number of icebergs or growlers per message, and limit-setting icebergs broken down by reporting source in 2017.

During the 2017 Ice Season, IIP incorporated the analysis of satellite imagery within IIP's OPAREA into the watch routine. Daily satellite passes over the IIP area of interest were processed and analyzed for targets that could be icebergs. IIP watchstanders then added high confidence targets that did not correlate with ship traffic into the iceberg model. Further details regarding the incorporation of satellite reconnaissance into IIP's operations is addressed in the Iceberg Reconnaissance Operations section.

A total of 19,264 icebergs, growlers, and radar targets were reported to IIP during the 2017 Ice Season. IIP watchstanders reviewed each report for accuracy and validity before the data were entered into BAPS. This included reviewing environmental conditions, other recent reconnaissance, and the detection method of each report. Of the 19,264 icebergs, growlers, and radar targets 11,977 (62%) were incorporated into the model.

Table 2 and **Figure 21** show that the majority of icebergs, growlers, and radar targets incorporated into the model were from commercial reconnaissance and IRD flights. This season, IIP conducted 31 reconnaissance flights that accounted for 3,485 icebergs and growlers added or re-sighted in the BAPS model. Another 285 icebergs or growlers were observed on IRD flights but were not incorporated in the model because of concurrent commercial flights already accounting for the icebergs or icebergs located above 60°N. On average, 112 icebergs were observed per IRD flight. Commercial reconnaissance accounted for 6,360 icebergs incorporated into the model, an average of 19 icebergs per flight.

Also noteworthy this season was the 1,799 icebergs integrated into the model from 174 satellite reconnaissance SIMs. The Satellite Recon percentage (**Figure 21**) comprises 91 satellite images that were processed and analyzed entirely by IIP staff for the first time in IIP's 104-year history. The remaining 83 SIMs were processed and analyzed by C-CORE, St. John's, NL in support of the oil and gas industry. Of the 1,799 icebergs that were incorporated into the model, 694 were from IIP Satellite SIMs and 1,105 were from C-CORE Satellite SIMs.

The commercial reconnaissance data in **Table 2** and **Figure 21** are from SIM reports made by PAL Aerospace, under contract from multiple sources. **Figure 22** shows a breakdown of the contracting source for the PAL Aerospace flights that reported iceberg sightings**.** Three quarters of PAL Aerospace flights which reported icebergs were flown for Canadian Government organizations other than CIS. Industry flights funded by oil and gas companies were concerned with icebergs in the vicinity of offshore oil rigs. The smallest portion, 7%, of the PAL Aerospace flights were funded by CIS specifically for iceberg reconnaissance in areas designated by either IIP or CIS. While the majority of PAL Aerospace flights were contracted for reasons other than ice reconnaissance, they report iceberg sightings to CIS and IIP from every flight, supporting iceberg reconnaissance and maritime safety throughout the region.

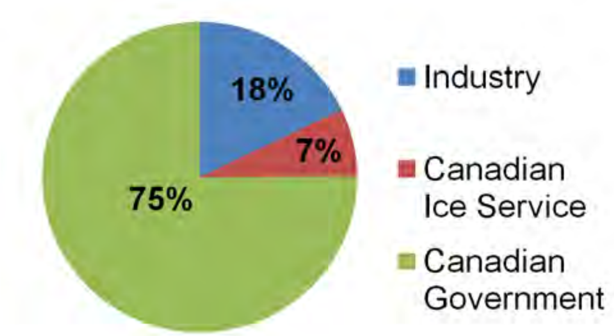

Figure 22. Breakdown of funding source for PAL Aerospace aerial reconnaissance flights which reported icebergs.

Limit Setting Icebergs

Of all the icebergs modeled by IIP, the most important were the ones that eventually defined the Iceberg Limit. Typically between three and seven icebergs set the Iceberg Limit at any time. Following the trend from the past year, PAL Aerospace flights, which typically focus on interior reconnaissance, were the largest initial sighting source (40%) for limit setting icebergs. Compared to 2016 where IIP reconnaissance accounted for 43% of limit setting icebergs, IIP only accounted for 29% in 2017. The likely decrease in percentage of limit setting icebergs reported by IIP was caused by a decrease in flights flown by IIP in 2017 and the increase in satellite reconnaissance. Limit setting icebergs initially sighted from satellite imagery sharply rose from 2% in 2016 to 22% in 2017.

Despite the rise in alternate reconnaissance methods, IRDs remain a critical component balancing safety and mobility for transatlantic shipping. In the 2017 Ice Season, the limit stretched approximately 510 NM east of St. John's at its maximum extent of 40°30'W on 04 June, and approximately 450 NM south of St. John's to 40°15'N on 16 April. These extreme extents of the Iceberg Limit exceed the range of commercial reconnaissance requiring IRDs for limit validation.

Observing the exact location of limit setting icebergs, especially those in the vicinity of transatlantic shipping lanes, by IRD's continued to be a critical part of exercising due care in the completion of IIP's mission. Further, IRDs provided critical validation needed for satellite image analysis as well as validating drift and deterioration model results. As improvements to environmental models and advances in modeling techniques are made, coupled with increased training, expertise, and software development for satellite-based iceberg detection, in situ validation of analysis results will be critical to ensuring safe, effective, and intelligent application of these advances. Dedicated IRD flights concurrent with satellite passes to validate analysis results will provide improved confidence in satellite iceberg detection.

Iceberg Reconnaissance Operations

Ice Reconnaissance Detachment

The IRD is a sub-unit under CIIP, which is partnered with ASEC. During the 2017 Ice Season, nine IRDs deployed to observe and report icebergs, sea ice, and oceanographic conditions in the North Atlantic Ocean. All observations were transmitted to the IIP OPCEN in New London, CT, where they were entered into BAPS and processed. The IIP OPCEN then created and distributed the NAIS iceberg warning products to the maritime community.

Throughout the 2017 Ice Season, IRDs operated out of IIP's base of operations in St. John's, NL for a total of 72 days and conducted 30 ice reconnaissance patrols. Two days prior to the first IRD, ASEC flew an HC-130J to Groton, CT, to provide required Aviation Mission Specialist (AMS) training for IIP personnel. Five IIP personnel returned to ASEC with the aircraft and provided pre-season training for ASEC personnel the following day. The 2017 flight season spanned 136 days, which is 28.6 days shorter than the five year (2012-2016) average of 164.6 days. The first IRD departed Elizabeth City, NC for St. John's, NL on 23 February, and the last IRD returned to New London on 06 July. A summary of IRD operations is provided in **Table 3.** From a historical perspective, this year is considered an extreme iceberg season based on the number of icebergs crossing south of 48°N. Additionally, this season, icebergs were present south of 48°N for a total of 193 days. The wide distribution of icebergs within the IIP OPAREA and persistent presence of icebergs south of 48°N required significant aircraft resources to accomplish necessary reconnaissance.

IRD	Deployed Days	Iceberg Patrols	Transit Flights	Patrol en Route	Logistics Flights	Flight Hours
1	10	3	2	0	0	34.1
2	9	2	2	0	0	25.1
3	9	3	2	0	0	30.7
4	9	4	1	1	0	40.7
5	8	3	2	0	0	31.1
6	8	4	2	0	0	37.7
7	1	0	1	0	0	3.6
8	9	5	1	1	0	47.9
9	9	4	2	0	0	41.6
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	0	0	0	0	0	0
Total	**72**	**28**	**15**	**2**	**0**	**292.5**

Table 3: Summary of 2017 IRD operations.

Aerial Iceberg Reconnaissance

Aerial iceberg reconnaissance operations were conducted using the HC-130J. The aircraft is equipped with two radars and an Automatic Identification System (AIS) integrated into the mission system suite. The ELTA-2022 360° X-Band

(ELTA) radar is capable of detecting and discriminating surface targets. The HC-130J Tactical Transport Weather Radar (APN-241) is capable of detecting surface targets but not identifying them. The AIS receives information transmitted by AIS equipped ships for positive identification and is used to differentiate vessels from icebergs on the radar.

The ability to employ operable ELTA radar significantly enhances reconnaissance capabilities. The 360° coverage provided by the ELTA radar supports the use of 25-NM track spacing for patrol planning. Under calm conditions, IIP is able to expand track spacing to 30 NM, while maintaining a 95% probability of detection (POD) of small icebergs (15 to 60 m). Calm environmental conditions permitted the use of 30-NM track spacing during six patrols this season, which allowed IIP to cover 20% more patrol area in the same amount of time.

When the ELTA radar is inoperable, the IRD must fly patrols under "visual-only" specifications using 10-NM track spacing. ELTA radar causalities not only reduce the number of radar-detected icebergs, but result in longer and less efficient patrols. Visual-only patrols with reduced track spacing cover 40% less area in a given time period, requiring two patrols to cover the same area. Further, patrols are limited to areas with pristine environmental conditions; clear skies and visibility to the surface are requirements for visual-only patrols which rarely occur in IIP's meteorologically active OPAREA.

As shown in **Figure 23**, IIP recorded an increased number of radar-observed icebergs during the 2017 Ice Season compared to the 2016 Ice Season **(Table 4)**. This increase in radar-observed icebergs and subsequent decrease in visual only is attributed to zero ELTA casualties during the 2017 Ice Season. In comparison, during the 2016 Ice Season, the ELTA radar experienced a casualty that rendered it inoperable on three separate IRDs

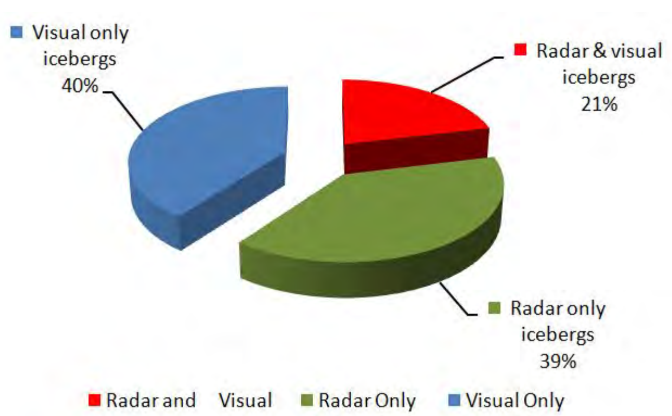

Figure 23. Summary of iceberg detections by method for 2017.

Year	Radar & visual icebergs	Radar only icebergs	Visual only icebergs
2012	47%	10%	43%
2013	46%	17%	37%
2014	43%	5%	52%
2015	29%	45%	26%
2016	20%	32%	48%
2017	21%	39%	40%

Table 4: Historical iceberg detections by method.

In 2017, the HC-130J fleet began its Minotaur mission system retrofit. The Minotaur mission system architecture is used on multiple platforms across the departments of Defense and Homeland Security. Missionization with the Minotaur Mission System Suite involves modifying the aircraft to incorporate the radar; sensors; and remaining command, control, communications, computers, intelligence, surveillance and reconnaissance equipment that allows aircrews to gather and process information for transmission to surface and shore operators.

IRD Operational Summary

IIP's first IRD arrived in St. John's on 23 February 2017 and conducted its first patrol the following day. The first flight flew eastward to Flemish Pass, northeastward along the 1000-m contour to Sackville Spur, the west side of Flemish Cap, and then southward along the 1000-m contour to 44°N. This initial flight confirmed that no icebergs drifted outside of the Southern Iceberg Limit in the offshore branch of the Labrador Current. A second flight on 25 February patrolled along the Labrador Coast to 59°N and detected 546 icebergs mostly within the sea ice edge. The final flight of this IRD on 01 March, covered both the Western and Eastern Iceberg Limits and detected 28 icebergs in the Newfoundland Sea and inside of the 1000-m contour. The aircraft diverted for a search and rescue case near Greenland and recovered in Goose Bay. The main population of icebergs remained well north of the transatlantic shipping lanes after IRD 1.

IRD 2 returned to St. John's on 08 March but poor weather throughout the period limited the IRD to just two patrols. The first searched the Labrador Current to 43°30'N and confirmed that no icebergs were adrift outside of the Southern Iceberg Limit. The second patrol searched through Flemish Pass, Sackville Spur, and the over Flemish Cap. This patrol detected 10 icebergs that verified the location of the Eastern Iceberg Limit.

During IRD 3, two HC-130J's, one legacy mission system and one Minotaur system, were deployed to conduct testing. Only two test flights with the Minotaur equipped aircraft were conducted due to aircraft maintenance and weather, limiting IIP's opportunity to test the Minotaur system. IIP completed a comprehensive report documenting lessons learned from this initial test of the Minotaur system with icebergs. Three Minotaur-outfitted aircraft are expected to be available for the 2018 Ice Season. Between the two aircrafts, IIP conducted three patrols of the Southern, Eastern, and Western Iceberg Limits. The Southern Iceberg Limit patrol detected only a small number of icebergs in this region.

During IRD 3, a fourth patrol, originally planned to fly northward along the Labrador Coast, shifted its focus to revisit the Southern Iceberg Limit as a result of iceberg reports following the late March storms. This patrol, on 29 March, detected 114 icebergs in the same area that IIP patrolled just four days earlier. **Figure 24** illustrates reconnaissance results from the 24 and 25 March flights in the left panel and results from the 29 March flight on the right. This figure highlights the dramatic change of positions for the limit-setting icebergs as a result of the intense storm systems passing through the IIP OPAREA during the last week of March.

IRD 4 arrived in St. John's on 05 April, after conducting a patrol south of the Avalon Peninsula while en route. This flight located 105 icebergs south of the Avalon Peninsula. A second flight on 06 April to 43°N located 26 icebergs over the eastern Grand Banks in the vicinity of the Southern Iceberg Limit, just to the west and outside of the main core of the Labrador Current.

The IIP iceberg drift model forecasted this grouping of icebergs to drift further south, closely following the bathymetric contours of the southeastern Grand Banks to a location further south and west of the Tail of the Grand Banks. However, the location of these icebergs with respect to the Labrador Current kept them from drifting further south. During this flight, IIP sighted the southernmost iceberg of the year at 43°14'N, 49°04'W. Two Eastern Iceberg Limit patrols located very few icebergs along the 1,000-m contour and on the west side of Flemish Cap. Another patrol that flew southwest of the Avalon Peninsula, the Gulf of St. Lawrence and into the Strait of Belle Isle located 159 icebergs total, confirming the large iceberg population surrounding Newfoundland.

From 20 to 27 April, IRD 5 flew only three patrols due to aircraft mechanical issues and poor weather in the OPAREA. A Southern Iceberg Limit patrol detected five icebergs with only one in the Labrador Current south of 45°N. An Eastern Iceberg

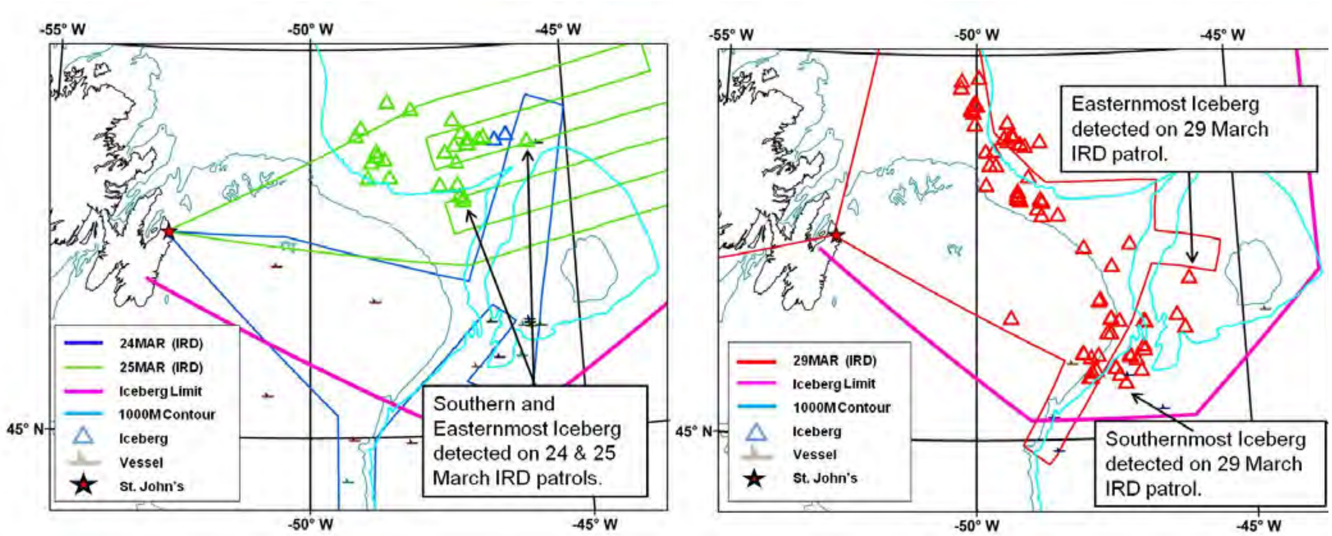

Figure 24. Reconnaissance results from the 24 and 25 March 2017 flights in the left panel and results from the 29 March 2017 flight on the right.

Limit that patrolled over Sackville Spur and Flemish Cap found zero icebergs, validating the iceberg distribution remained focused near shore. A third patrol surveyed Notre Dame Bay and the offshore branch of the Labrador Current up to 55°N, locating 382 icebergs.

IRD 6 conducted a total of four flights between 04 and 07 May. Two patrols searched around the island of Newfoundland to validate the location of the Southwestern, and Western Iceberg Limits. The Western Limit flight located 345 icebergs in the Gulf of St. Lawrence and Notre Dame. The Southwestern patrol observed an additional 36 icebergs south of the Avalon Peninsula. By contrast, IIP found zero icebergs while searching the Southeastern and Southern Iceberg Limits.

IIP cancelled IRD 7, originally scheduled for 17 to 25 May for various reasons that included a one-day delay in departure from ASEC, an aircraft mechanical issue, and a stagnant low pressure system over Newfoundland. The impact of cancelling this detachment was mitigated because the primary iceberg population remained generally confined to Newfoundland. PAL Aerospace continued active patrolling, conducting six iceberg reconnaissance flights in support of CIS and the oil and gas industry. PAL Aerospace also flew 12 additional patrols during this period to support other Canadian Government interests during the time that IRD 7 was scheduled to be deployed.

However, on 29 May, a small grouping of icebergs was reported by a vessel in a position southeast of Flemish Cap and approximately 90 NM east of the published Iceberg Limit. This sighting was not consistent with the observed iceberg distribution pattern and either drifted over the Flemish Cap in an eastward branch of the Labrador Current or was brought to this location via an eastward flowing jet from the main branch of the Labrador Current south of Flemish Pass. This report was the easternmost sighting for the year in position 46°33'N, 43°45'W. This sighting is discussed in greater detail in the Operations Center Summary.

IIP deployed IRD 8 between 31 May and 08 June. This detachment conducted five patrols to validate the location of the Iceberg Limits. Results from these flights detected 15 icebergs around the Avalon Peninsula. The Southwestern Iceberg Limit on 08 June exceeded the extreme climatological Iceberg Limit in this area. Offshore flights showed that very few icebergs were present to threaten the transatlantic shipping lanes. A sixth sortie to 60°N along the 1,000-m contour assessed the northern feeder population detecting 699 icebergs along the Labrador Coast.

With the results from IRD 8, IIP elected to cancel the next detachment scheduled for 14 to 22 June and planned to deploy its final detachment on 28 June. With the iceberg population relatively close to St. John's, PAL Aerospace again provided invaluable data during the time between IIP detachments.

IIP conducted its final IRD of the 2017 Ice Year from 28 June to 06 July. This detachment conducted patrols of the Southwestern/Southern, Eastern, and Western Iceberg Limits. These searches verified that only three icebergs remained around the Avalon Peninsula and three along the 1,000-m contour, north of 48°N. The Western patrol found 319 icebergs in the Gulf of St. Lawrence and Strait of Belle Isle.

The fourth and final patrol of the year detected 376 icebergs along the Labrador Coast and into Davis Strait. This flight patrolled to 67°28'N. The purpose for flying this far north was both to assess the iceberg population along the Labrador Coast and to evaluate the Extra Wide Swath mode of the European Space Agency's (ESA) C-Band SAR satellite system (Sentinel-1) satellite for support the U.S. Coast Guard Cutter (USCGC) MAPLE scheduled to transit this region later in July.

Figure 25 shows a summary of IIP's deployment days during the 2017 Ice Season. Each season, the prevailing OPAREA weather contributes significantly to the number and effectiveness of reconnaissance patrols. Operational days include transit days to and from the forward operating base in St. John's, NL. The IRD normally takes one crew rest day each deployment in accordance with the USCG Aviation Safety Regulations. Crew rest days are scheduled to coincide with poor weather days when feasible, to maximize operational iceberg reconnaissance flight days. On seven occasions in 2017, flights were cancelled due to poor weather.

IRD personnel detected 3,770 icebergs which accounted for 33.1% of the total icebergs added to the IIP database during the 2017 Ice Season. During aerial reconnaissance, icebergs are detected in one of three ways: (1) combination of radar and visual, (2) radar only, or (3) visual only.

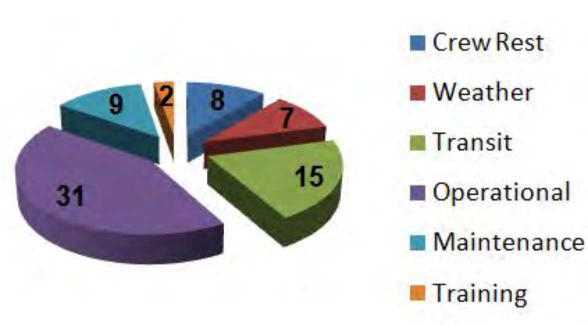

Figure 25. Summary of 2017 IIP deployment days.

This year, 21% of the icebergs were detected by both radar observations and visual sightings. The remaining icebergs were either detected only by radar (39%) or by visual detection alone (40%) (**Figure 23**). The percentage of visual only detections decreased this season by 8% compared to the 2016 Ice Season. This decrease in visual only detections can be attributed to the previously described advantage of having operable ELTA radar for all nine IRDs. However, visual-only detections remain a significant portion of the detection method as a result of optimizing reconnaissance resources while on patrol. In areas of high iceberg concentration with favorable environmental conditions, IRD's will focus visual-only observations close to the aircraft while employing radar only observations away from the flight path enabling maximum detection efficiency.

2017 Flight Hours

Figure 26 shows the breakdown of the 292.5 operational flight hours IIP used during the 2017 Ice Season. The flight hours are broken down into three categories: transit hours, patrol hours, and logistics hours. Transit hours are hours the aircraft transited to and from specific locations in support of the IIP mission. There were 89.2 hours used this season for transits. These flights are generally to or from St. John's, NL. Transit hours for the 2017 Ice Season also include a planned IIP Northern Survey outside of IIP's OPAREA above 60˚N in support of USCGC MAPLE during IRD 9. Flight hours for an unscheduled search and rescue divert to investigate a 406-megahertz Emergency Position Indicator Radio Beacon (EPIRB) signal during IRD 1 are not included.

Patrol hours are the hours associated with iceberg reconnaissance including flight time to and from the reconnaissance area. IIP flew 203.3 patrol hours this season. On

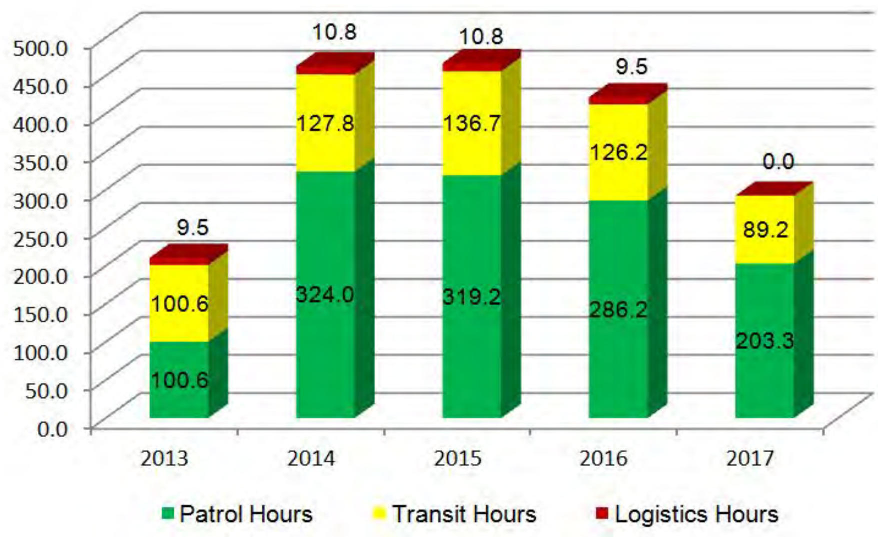

Figure 26. Summary of flight hours (2013-2017).

two occasions, patrols were conducted during transits between the United States and St. John's, NL. These patrols tend to require additional transit hours due to starting or ending positions north or east of St. John's, NL. Patrols during transit remain a mitigation tool for IIP to reduce the impact of poor weather or aircraft maintenance. Logistics hours are the hours used to support the IIP mission, but do not fall into the previous two categories.

Logistics hours accrue when a Coast Guard aircraft is used to transport parts for an aircraft deployed on an IIP mission. In 2017, zero logistics hours were used.

The number of flight hours needed for IIP to monitor the iceberg danger to transatlantic mariners is closely linked to the number of icebergs observed or modeled south of 48°N. **Figure 27** shows a comparison of flight hours to the number of icebergs drifted south of 48°N from 2007 to 2017. The red line indicates IIP's total flight hours. The blue bars indicate the number of icebergs observed or drifted south of 48°N. As in previous seasons, IIP was allotted 500 Maritime Patrol Aircraft flight hours for its operations in 2017. IIP used 292.5 hours compared to 429.1 in 2016.

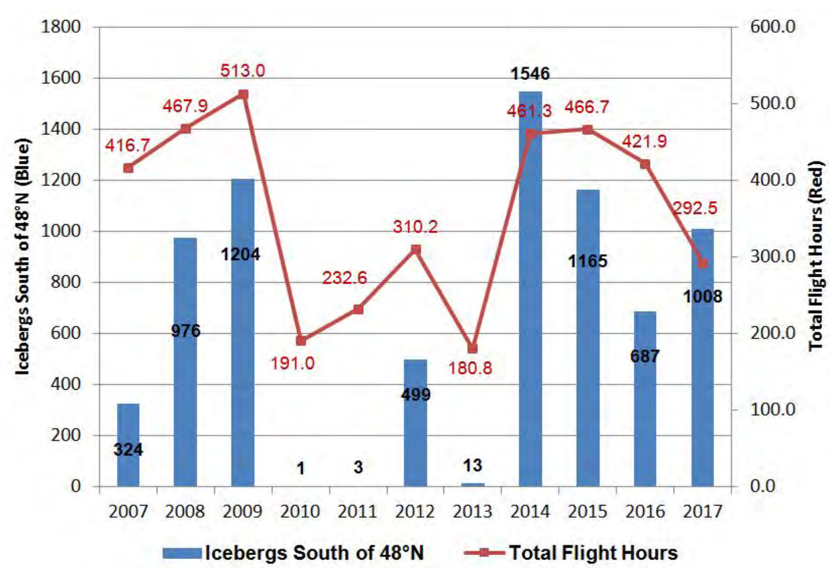

Figure 27. Flight hours vs. icebergs south of 48°N.

Other Iceberg Reconnaissance Activities

NAIS Collaboration

IIP continued to leverage its NAIS partnership with CIS to maximize efficient use of aerial reconnaissance resources. IIP coordinated flight plans with CIS to minimize overlap and maximize efficiency of reconnaissance operations. **Figure 28** depicts the NAIS flight hours for 2017. Data provided includes hours flown by each service. CIS contracted PAL Aerospace for 164 patrol hours resulting in a total of 367.3 patrol hours in support of NAIS reconnaissance.

The NAIS region is divided into five areas based on the risk of iceberg collision for vessels in the transatlantic shipping lanes. Northern areas are monitored to determine the overall iceberg population early in the season and to predict the anticipated threat of icebergs drifting south in the Labrador Current. Once the Iceberg Limit extends southward toward the transatlantic shipping lanes and retracts northward in late summer, the focus of iceberg reconnaissance shifts accordingly. To illustrate this tiered approach, **Figure 29** shows a one-day snapshot indicating the most recent reconnaissance coverage for areas across the NAIS region on 04 September 2017.

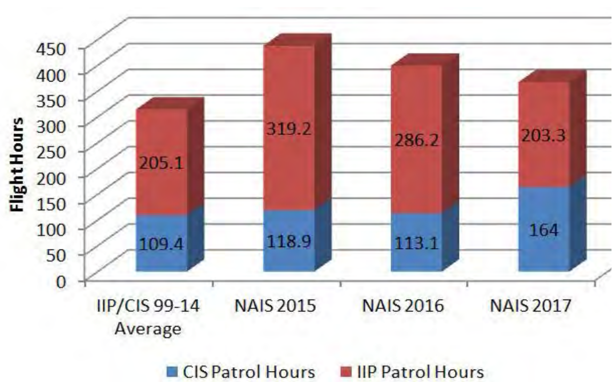

Figure 28. NAIS flight hours (2015-2017).

PAL Aerospace, Ltd.

From October through December, PAL Aerospace conducted 11 sorties focused south of 55°N and near the Newfoundland and Labrador coasts. These flights detected a total of 8 icebergs during this period. No icebergs were detected south of 50°N until mid-December. In addition, five Transport Canada flights reported 3 icebergs and 12 radar targets, along the Labrador Coast north of Goose Bay.

PAL Aerospace continued a very active flight schedule, conducting 7 flights in January, 29 flights in February, and 56 flights in March for a total of 92 flights between January and March. Of these flights, 19 were conducted specifically for iceberg reconnaissance for CIS and the oil and gas industry. In January and February, flights searched in Notre Dame Bay and the Newfoundland Sea out to the 1,000-m depth contour and generally up to 52°N latitude. Beginning in late February, iceberg reconnaissance flights shifted southward to

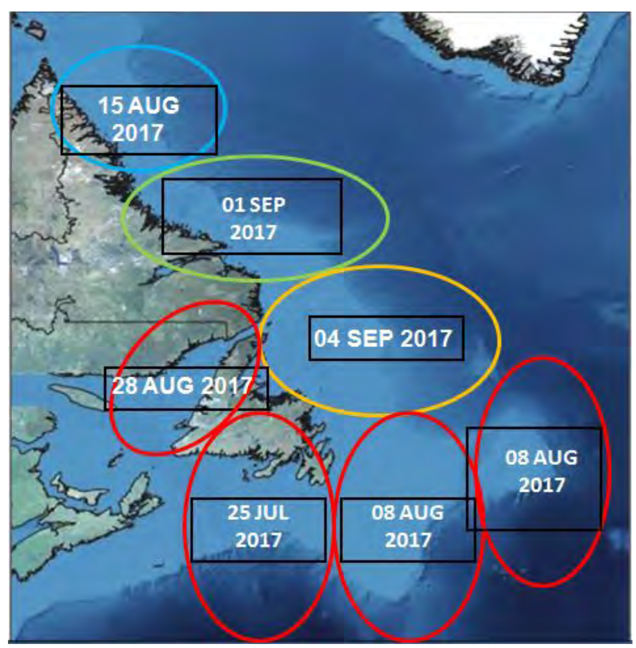

Figure 29: NAIS coverage status on 04 September 2017.

investigate iceberg population in the Flemish Pass with the first flight in support of the oil and gas industry occurring on 10 March. The remaining PAL Aerospace flights primarily supported other Canadian Government interests but also served as an important source for iceberg information.

For the remainder of the year, PAL Aerospace flew 14 iceberg reconnaissance flights in support of CIS to monitor the iceberg danger around Newfoundland and an additional 45 iceberg flights for the oil and gas industry. PAL Aerospace also relayed reports from iceberg observations that were collected during flights in support of other Canadian Government interests that were incorporated into IIP's daily Iceberg Limit product.

Ship Interactions

Most of the HC-130J's on-scene patrol time is focused on locating and classifying icebergs using visual and radar reconnaissance methods. During patrols, the IRD will also communicate directly with the maritime community to request recent iceberg sighting information. This communication takes two forms: a sécurité broadcast to all vessels in vicinity of the aircraft, and direct calls to vessels identified by AIS. The information coming from the individual vessels proves especially useful during periods of reduced visibility or when numerous small vessels not equipped with AIS are present in the reconnaissance area. Vessel observation information is also valuable for confirmation of data provided by the aircraft's radar. During the 2017 season, IRDs made 86 general sécurité broadcasts, 38 direct vessel callouts, and provided one urgent iceberg warning broadcast to report an iceberg sighted near the iceberg limit.

Satellite Reconnaissance

For the first time in its history, in January 2017 IIP began integrating IIP OPCEN-analyzed satellite reconnaissance data into its iceberg warning products. In accordance with its commercial SAR satellite reconnaissance Concept of Operations (CONOPS), IIP focused on the northern region of its operational area north of 50°N (**Figure 30**). This region typically has less shipping and larger icebergs that can more easily be discerned accurately.

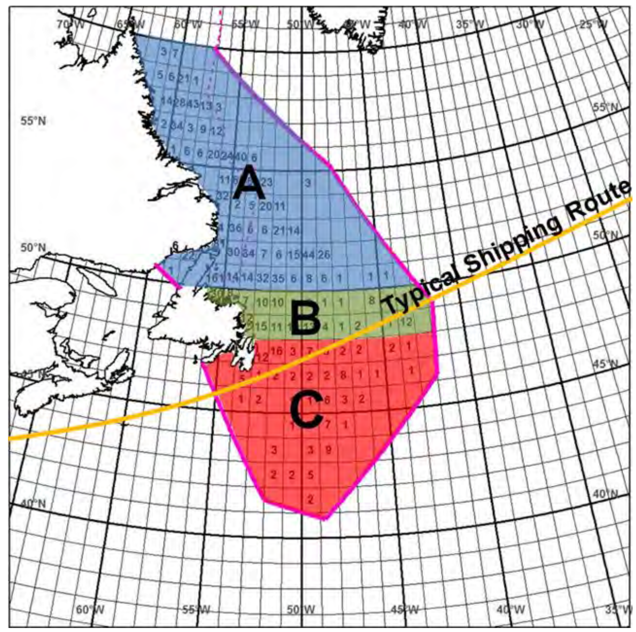

Figure 30. IIP Satellite Reconnaissance Strategy Region from IIP Satellite CONOPS. Iceberg Limit shown is typical for late May and early June.

This process used commercially-sourced iceberg detection software to streamline the analysis of satellite imagery. The primary source of satellite imagery was obtained from the ESA Sentinel-1A and 1B Satellites. In addition to a consistent collection schedule, Sentinel data are open source, no-cost imagery available online in near real-time. Satellite data analyzed by IIP watchstanders augmented the current aerial reconnaissance strategy and shipborne reporting.

During the 2017 Ice Season, the OPCEN processed 174 satellite standard iceberg messages (SIMs) resulting in 1,799 icebergs incorporated into BAPS. Ninety-one SIMs were downloaded and analyzed by IIP, adding 327 icebergs and resighting 367 icebergs into the model.

The remaining 83 (of 174) Sentinel-1 satellite-derived SIMs were analyzed by C-CORE in support of the oil and gas industry and provided to IIP as iceberg reports beginning in early February. Most of the icebergs reported by C-CORE were located south of 50°N. While this was in contrast to IIP's initial Satellite Concept of Operations to not incorporate satellite data south of 50°N without other corroborating evidence as to the targets' identity (IIP, 2016), IIP elected to incorporate this data into the database while employing aerial reconnaissance and AIS for verification. This input added 158 icebergs and resighted 947 icebergs in BAPS.

IIP also acquired 56 Canadian C-Band SAR satellite system (RADARSAT-2) images during the 2017 Ice Season through its partnership with NIC under the Northern View arrangement between NGA and Canada's Department of National Defence. As in 2016, having a dedicated person at NIC to manage RADARSAT-2 ordering requests proved invaluable toward the smooth collection of data. IIP intended to use RADARSAT-2 imagery for validation purposes and so requested imagery in the areas most likely to require aerial reconnaissance. However, due to weather and operational priorities, only two flights received aerial reconnaissance validation.

Prior to the 2017 Ice Season (October through December 2016) CIS also provided satellite data from the Canadian RADARSAT-2 satellite. CIS collected five RADARSAT-2 ScanSAR Narrow satellite images (300 kilometers swath, 50 m resolution), adding a total of 27 icebergs into the daily Iceberg Limit warning product.

Tailored Satellite Imagery Analysis: USCGC MAPLE Support

IIP provided tailored support to USCGC MAPLE, a 225-foot (ft), ice-strengthened buoy tender during the vessel's historic transit of the Northwest Passage. In cooperation with its NAIS partners and USCG District 17, from 14 to 18 August 2017, IIP crafted daily iceberg products while NIC provided detailed, daily sea ice products during transit through Baffin Bay, Davis Strait, and the Labrador Sea. **Figure 31** provides an example of IIP's tailored iceberg product indicating regions with 'Isolated', 'Few', and 'Many' icebergs. These terms, defined in **Table 5,** were developed in conjunction with the International Ice Charting Working Group. Construction of this chart employed the CIS Approaches to Resolute and Baffin Bay sea ice charts. This product provided a critical resource essential for the USCGC MAPLE's mission planning and situational awareness while transiting in iceberg rich waters. In addition, the tailored product included an evaluation of ESA's Polar Thematic Exploitation Platform (TEP). The Polar TEP is a cloud-based system that contains iceberg detection, drift modeling, iceberg density, and iceberg association processors. Use of cloud-based systems can address challenges with handling the large amounts of data and significant computing power needed to efficiently process satellite imagery.

Commemorative Wreath Drops

Each year, in conjunction with reconnaissance operations, IIP drops commemorative wreaths to remember the lives lost at sea in the North Atlantic Ocean. This year, IIP held a memorial service and wreath dedication to commemorate the 105th anniversary of the sinking of the RMS TITANIC. The ceremony was held at IIP in

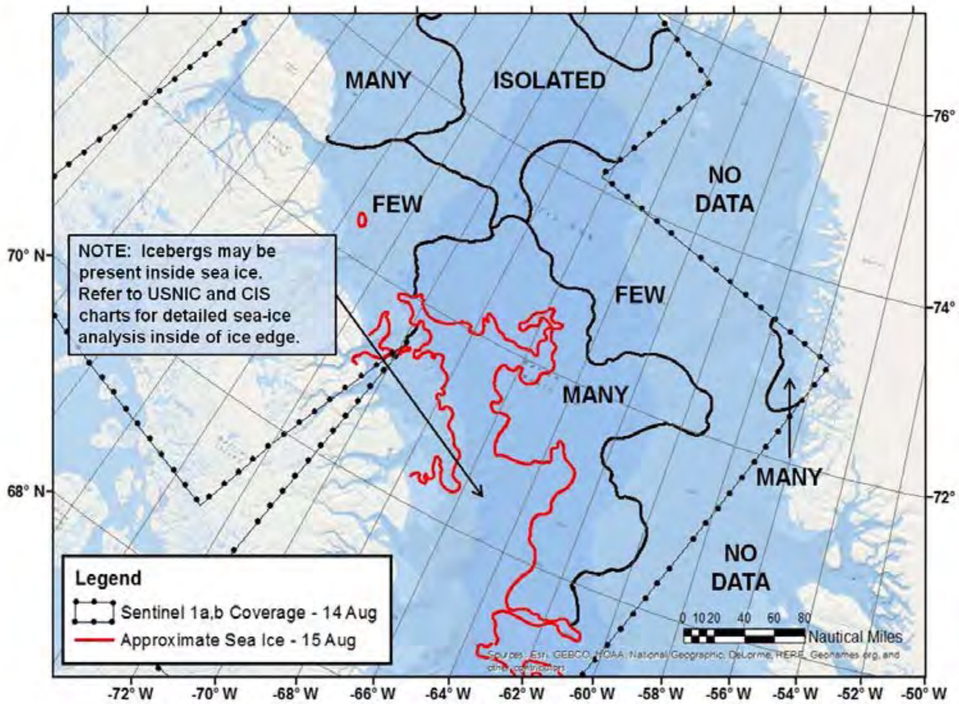

Figure 31. IIP tailored iceberg warning product provided to USCGC MAPLE on 15 August 2017 showing regions of 'Isolated', 'Few', and 'Many' icebergs based on Sentinel-1 satellite data.

Isolated	Few	Many
0-1 icebergs per 1° by 1° grid cell; or more than 45 NM between icebergs	2-6 icebergs per 1° by 1° grid cell; or 10-44 NM between icebergs	7 or more icebergs per 1° by 1° grid cell; or less than 10 NM between icebergs
Little maneuvering with steady course and speed.	Some maneuvering and reduced speed.	Frequent maneuvering and low speed.

Table 5. Description of 'Isolated', 'Few', and 'Many' terminology used in tailored USCGC MAPLE iceberg warning product.

New London, CT. All four wreaths dedicated during the ceremony were deployed from an HC-130J aircraft on 25 April 2017.

On 26 May 2017, IIP held a memorial ceremony at the USCG Academy Museum in New London, CT, commemorating the sacrifices of those serving as part of the Greenland Patrol during World War II. The wreath dedicated at the memorial service was deployed in the North Atlantic from an HC-130J aircraft on 06 June 2017.

USCG Commandant IIP Familiarization Visit

During IRD 6, the Commandant of the USCG, the U.S. Chargé d'affaires to Canada, the U.S. Consul General for the Atlantic Provinces, Halifax, the USCG Attaché to Canada, and the Commandant's official travel party travelled to St. John's, NL to participate in an IIP mission familiarization visit. On 05 May 2017, CIIP delivered an IIP operational brief followed by a question and answer period for the Commandant and VIPs. This briefing was held at the Executive FBO in Hangar 1. Torbay Aero Services and PAL Aerospace provided outstanding support for the visit. This briefing was followed by a patrol of the Western Iceberg Limit. During this patrol, the Commandant, his official travel party, and VIPs each spent time rotating through the various duty positions of a Coastguardsman on an iceberg reconnaissance patrol.

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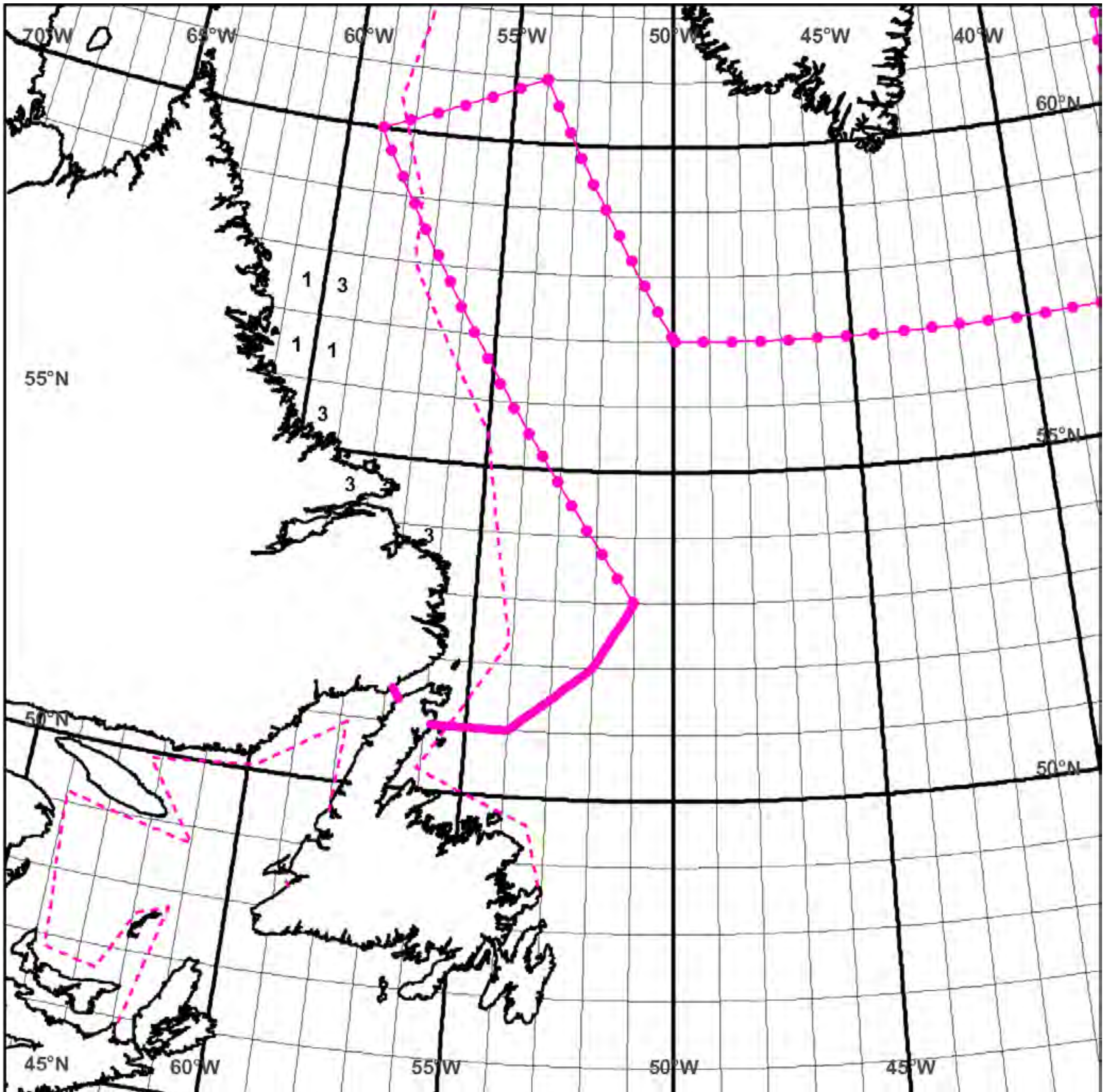
Semi-Monthly Iceberg Charts



NORTH AMERICAN ICE SERVICE (NAIS)

ICEBERG ANALYSIS FOR 0000 UTC

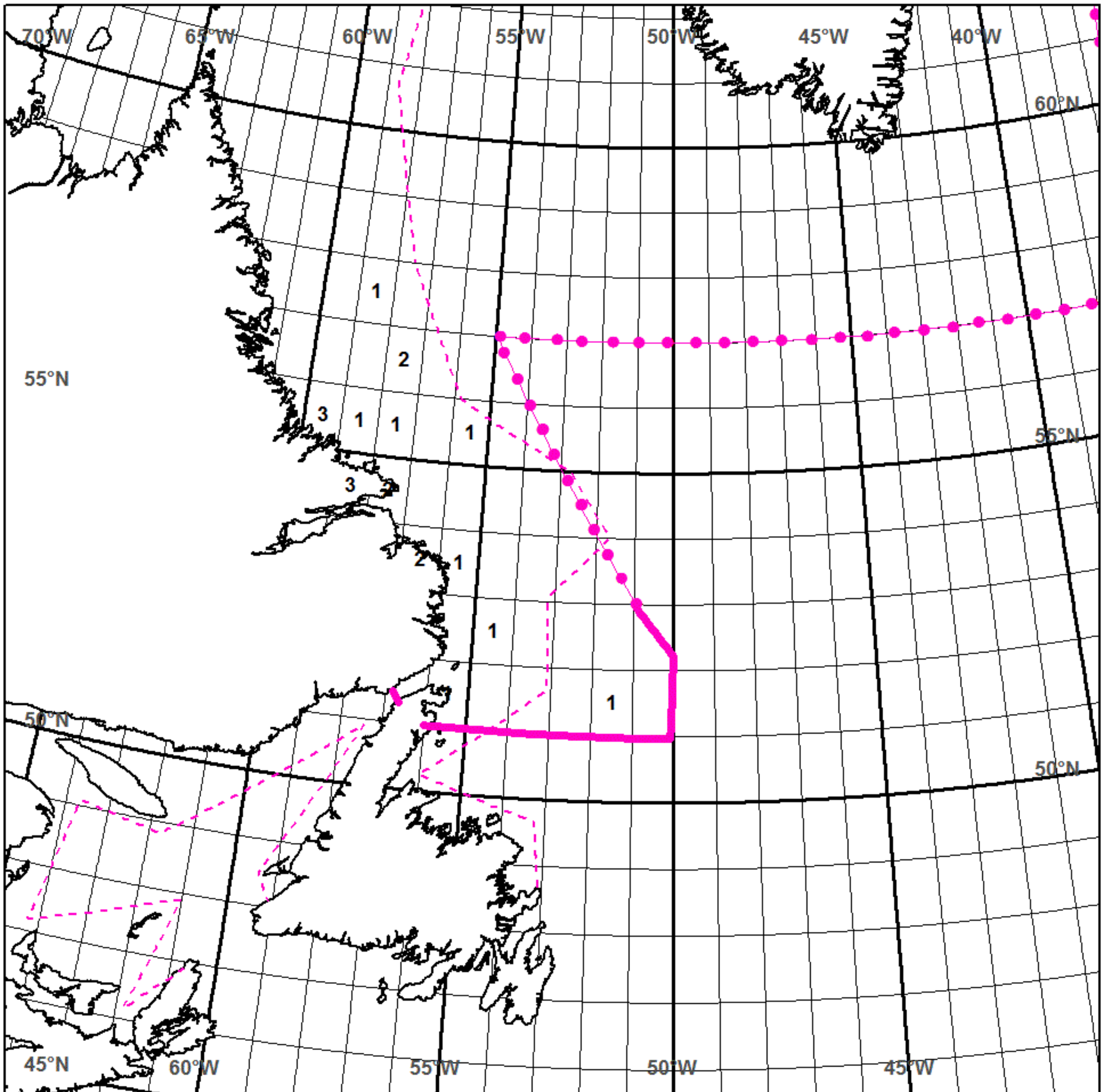
01 JAN 2017

- ESTIMATED ICEBERG LIMIT
- ICEBERG LIMIT
- SEA ICE LIMIT
- # ICEBERGS PER DEGREE SQUARE
- ⊗ RADAR TARGET OUTSIDE ICEBERG LIMIT

NOTE:

Significant reduction of iceberg limit due to recent reconnaissance (predicted deterioration).

For more information:
www.navcen.uscg.gov/iip
www.ice-glaces.ec.gc.ca
Most Recent Reconnaissance:
Interior Iceberg Flight 29DEC16.



NORTH AMERICAN ICE SERVICE (NAIS)

ICEBERG ANALYSIS FOR 0000 UTC

15 JAN 2017

ESTIMATED ICEBERG LIMIT

ICEBERG LIMIT

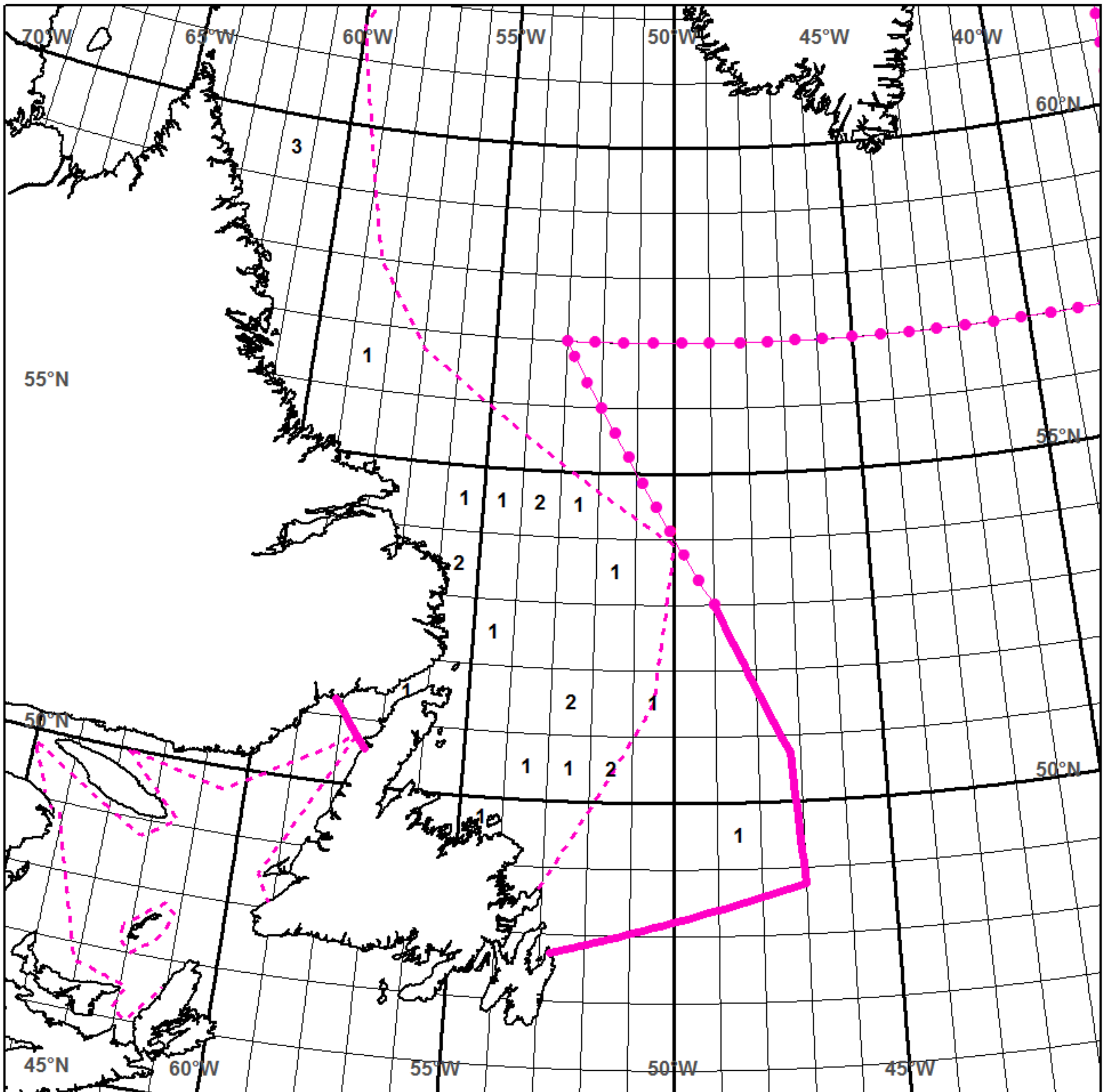
SEA ICE LIMIT

ICEBERGS PER DEGREE SQUARE

⊗ RADAR TARGET OUTSIDE ICEBERG LIMIT

NOTE:

For more information:
www.navcen.uscg.gov/iip
www.ice-glaces.ec.gc.ca
Most Recent Reconnaissance:
Interior Iceberg Flight 12JAN17.



NORTH AMERICAN ICE SERVICE (NAIS)

ICEBERG ANALYSIS FOR 0000 UTC

01 FEB 2017

ESTIMATED ICEBERG LIMIT

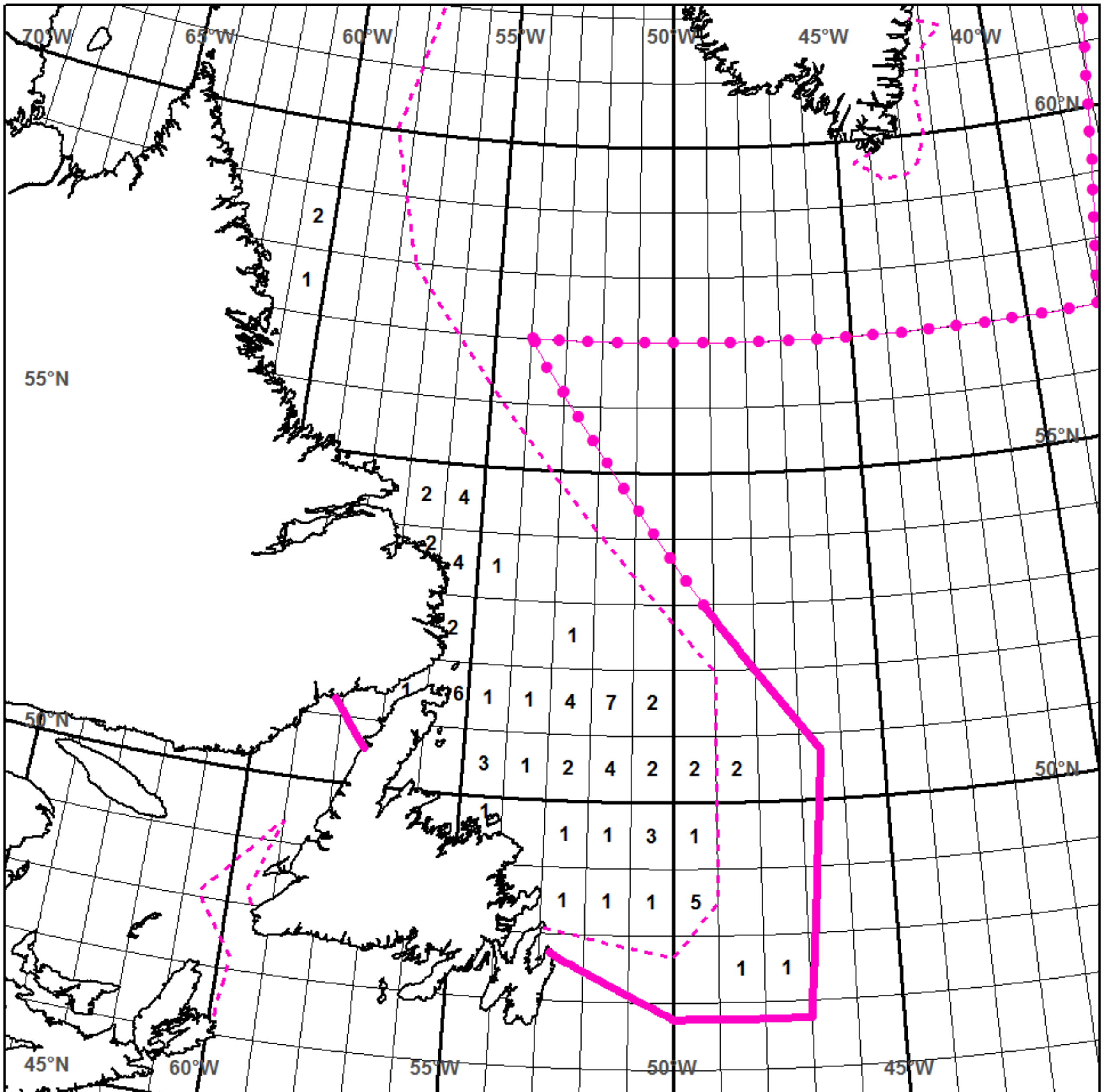
ICEBERG LIMIT

SEA ICE LIMIT

ICEBERGS PER DEGREE SQUARE

⊗ RADAR TARGET OUTSIDE ICEBERG LIMIT

NOTE:
For more information:
www.navcen.uscg.gov/iip
www.ice-glaces.ec.gc.ca
Most Recent Reconnaissance:
Interior Iceberg Flight 24JAN17.



NORTH AMERICAN ICE SERVICE (NAIS)

ICEBERG ANALYSIS FOR 0000 UTC

15 FEB 2017

ESTIMATED ICEBERG LIMIT

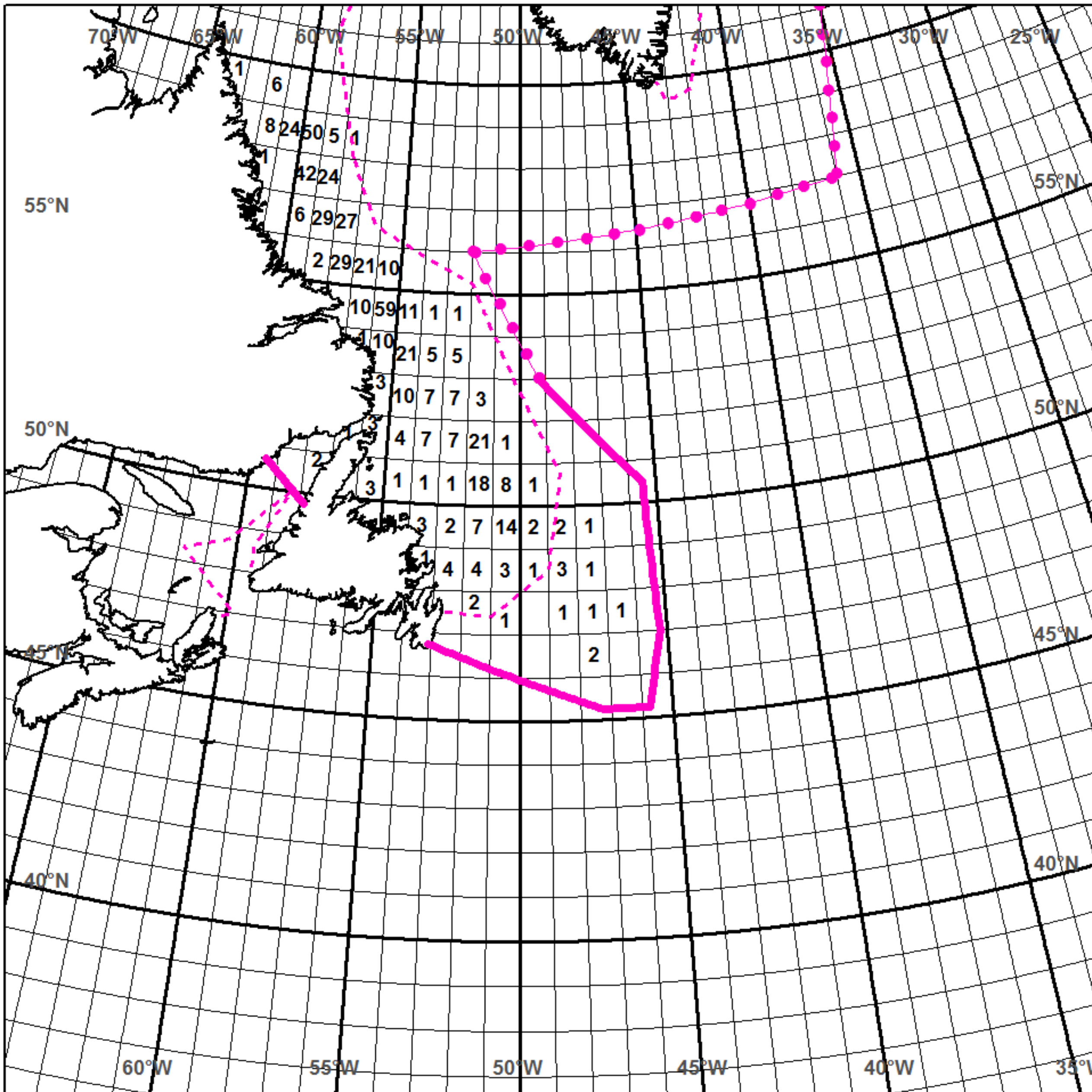
ICEBERG LIMIT

SEA ICE LIMIT

ICEBERGS PER DEGREE SQUARE

RADAR TARGET OUTSIDE ICEBERG LIMIT

NOTE:
For more information:
www.navcen.uscg.gov/iip
www.ice-glaces.ec.gc.ca
Most Recent Reconnaissance:
Western Limit Iceberg Flight 11FEB17.



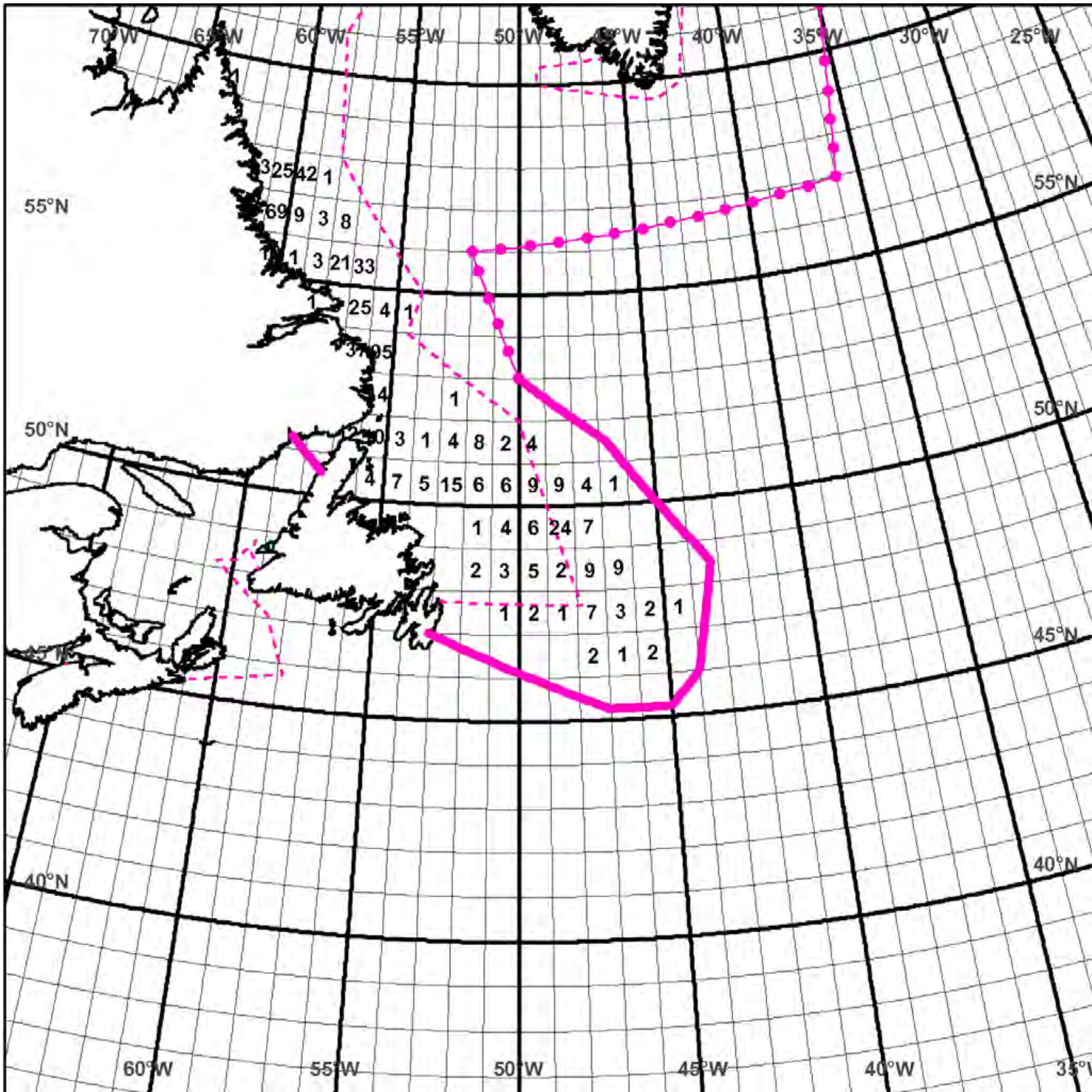
NORTH AMERICAN ICE SERVICE (NAIS)

ICEBERG ANALYSIS FOR 0000 UTC

01 MAR 2017

- ESTIMATED ICEBERG LIMIT
- ICEBERG LIMIT
- SEA ICE LIMIT
- # ICEBERGS PER DEGREE SQUARE
- ⊗ RADAR TARGET OUTSIDE ICEBERG LIMIT

NOTE:
For more information:
www.navcen.uscg.gov/iip
www.ice-glaces.ec.gc.ca
Most Recent Reconnaissance:
Northern Survey Iceberg Flight 25FEB17.



NORTH AMERICAN ICE SERVICE (NAIS)

ICEBERG ANALYSIS FOR 0000 UTC

15 MAR 2017

ESTIMATED ICEBERG LIMIT

ICEBERG LIMIT

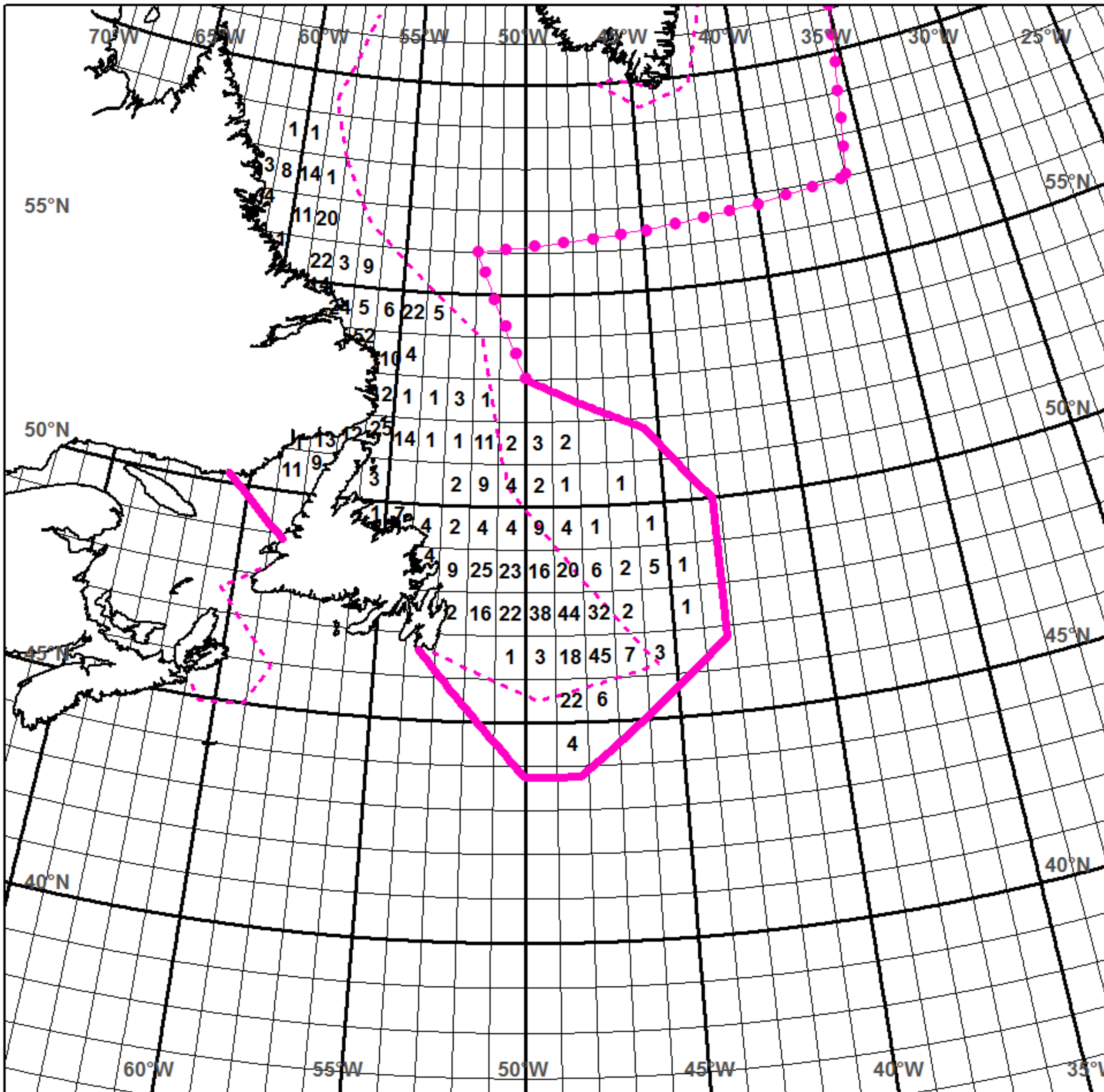
SEA ICE LIMIT

ICEBERGS PER DEGREE SQUARE

⊗ RADAR TARGET OUTSIDE ICEBERG LIMIT

NOTE:

For more information:
www.navcen.uscg.gov/iip
www.ice-glaces.ec.gc.ca
Most Recent Reconnaissance:
Southern Limit Iceberg Flight 09MAR17.



NORTH AMERICAN ICE SERVICE (NAIS)

ICEBERG ANALYSIS FOR 0000 UTC

01 APR 2017

ESTIMATED ICEBERG LIMIT

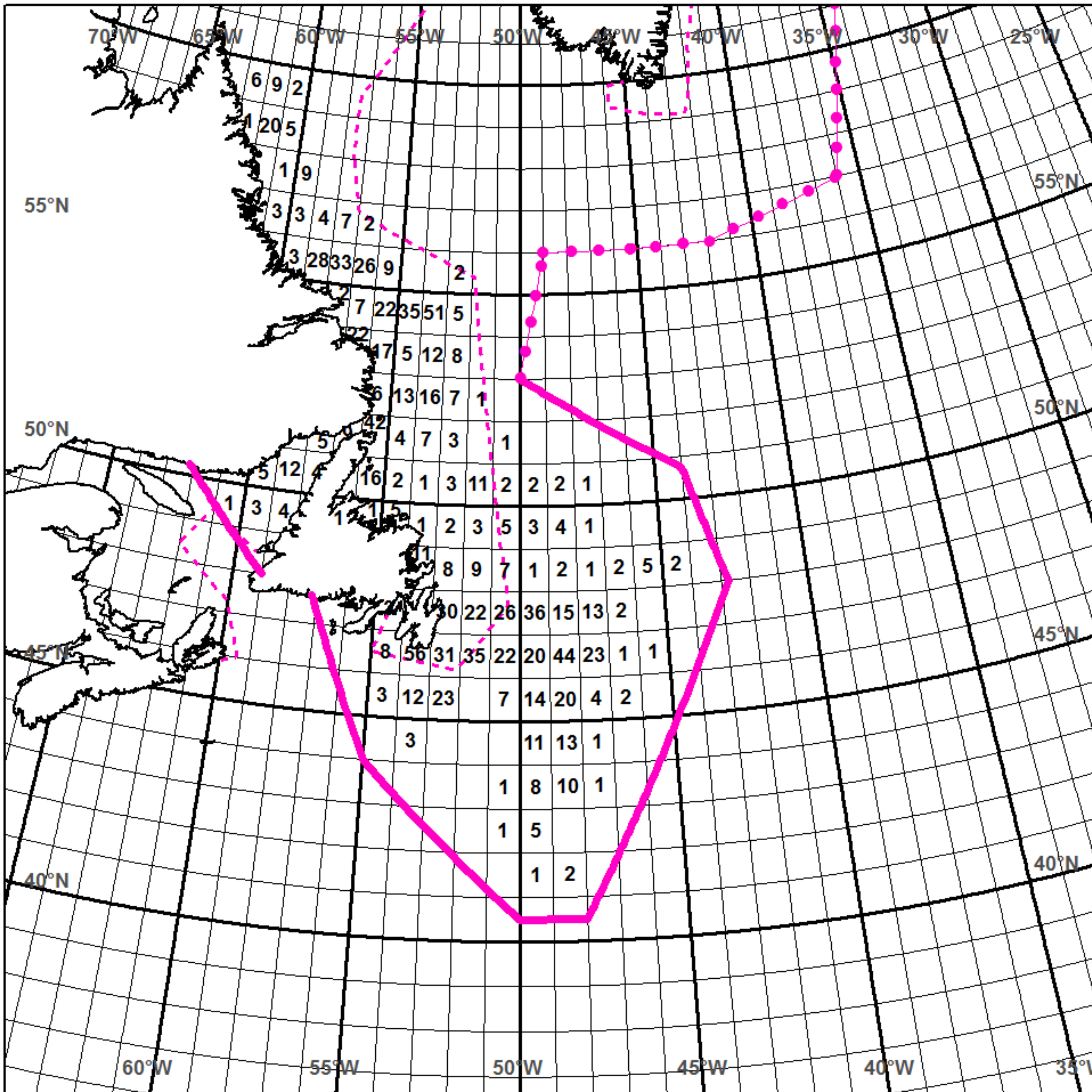
ICEBERG LIMIT

SEA ICE LIMIT

\# ICEBERGS PER DEGREE SQUARE

⊗ RADAR TARGET OUTSIDE ICEBERG LIMIT

NOTE:
For more information:
www.navcen.uscg.gov/iip
www.ice-glaces.ec.gc.ca
Most Recent Reconnaissance:
Southern Limit Iceberg Flight 29MAR17.



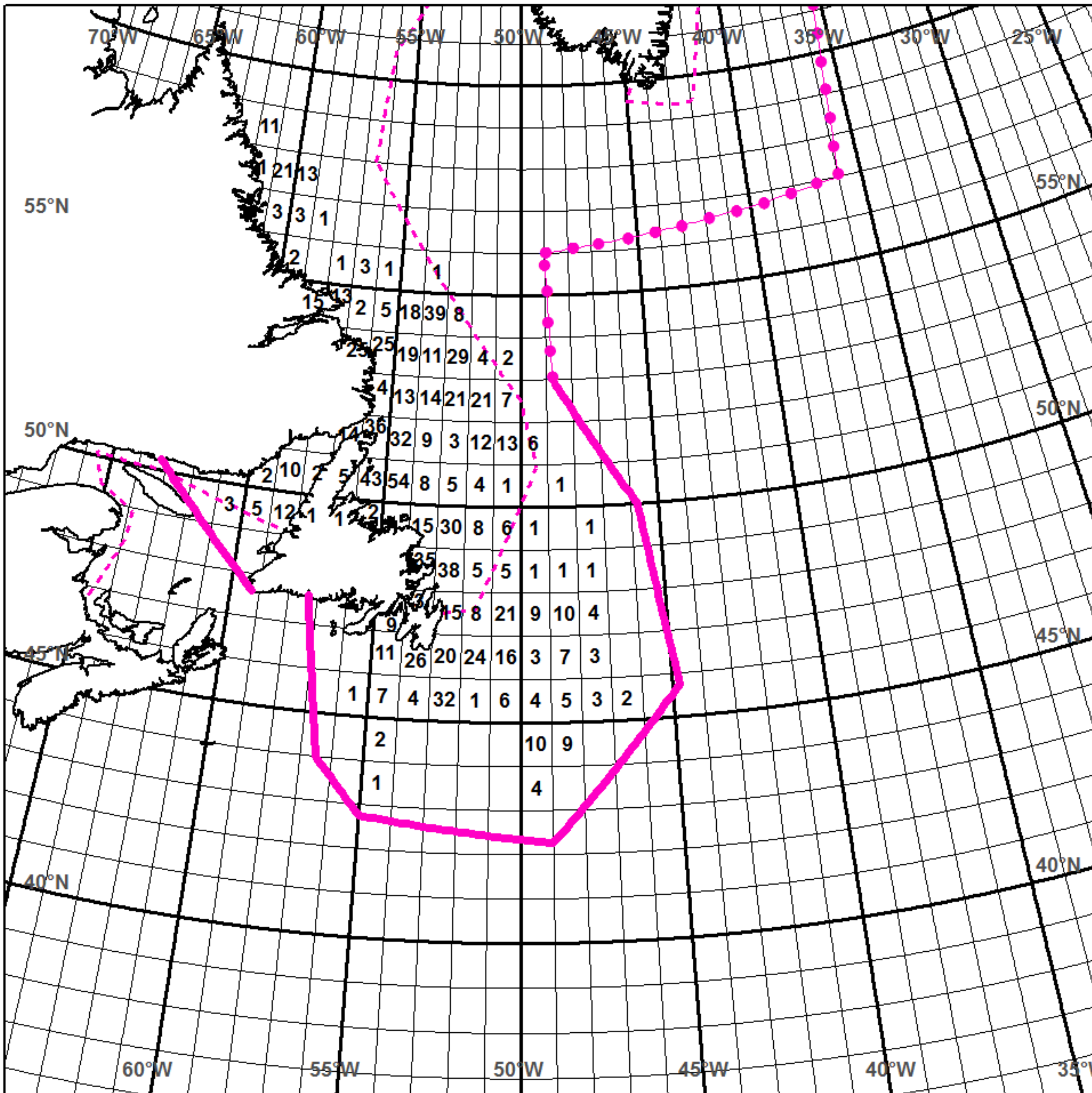
NORTH AMERICAN ICE SERVICE (NAIS)

ICEBERG ANALYSIS FOR 0000 UTC

15 APR 2017

- ESTIMATED ICEBERG LIMIT
- ICEBERG LIMIT
- SEA ICE LIMIT
- # ICEBERGS PER DEGREE SQUARE
- ⊗ RADAR TARGET OUTSIDE ICEBERG LIMIT

NOTE:
Today we commemorate the 105th anniversary of the sinking of the RMS Titanic.
For more information:
www.navcen.uscg.gov/iip
www.ice-glaces.ec.gc.ca
Most Recent Reconnaissance:
Eastern Limit Iceberg Flight 11APR17.



NORTH AMERICAN ICE SERVICE (NAIS)

ICEBERG ANALYSIS FOR 0000 UTC

01 MAY 2017

ESTIMATED ICEBERG LIMIT

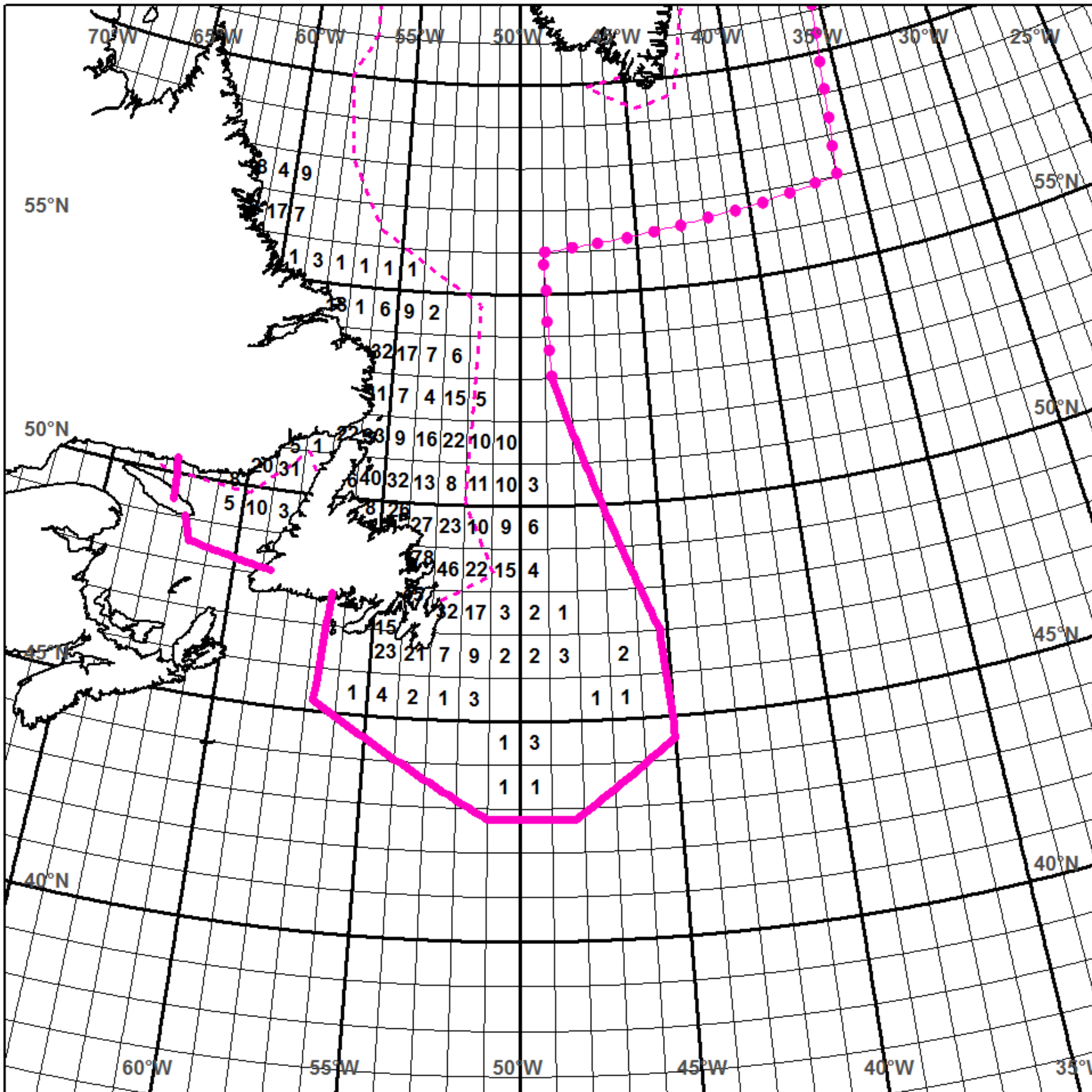
ICEBERG LIMIT

SEA ICE LIMIT

ICEBERGS PER DEGREE SQUARE

⊗ RADAR TARGET OUTSIDE ICEBERG LIMIT

NOTE:
For more information:
www.navcen.uscg.gov/iip
www.ice-glaces.ec.gc.ca
Most Recent Reconnaissance:
Eastern Limit Iceberg Flight 26APR17.



NORTH AMERICAN ICE SERVICE (NAIS)

ICEBERG ANALYSIS FOR 0000 UTC

15 MAY 2017

ESTIMATED ICEBERG LIMIT

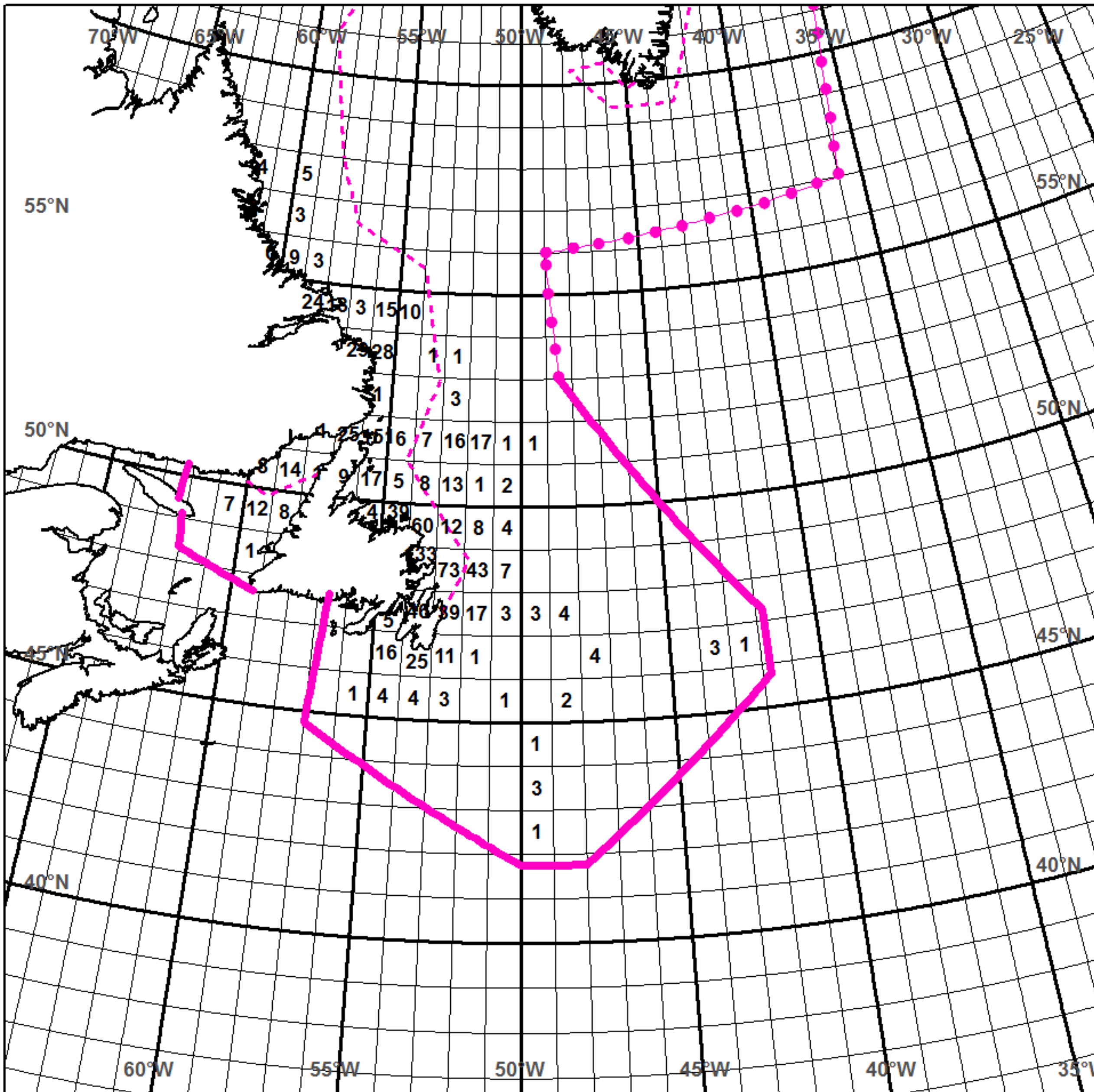
ICEBERG LIMIT

SEA ICE LIMIT

\# ICEBERGS PER DEGREE SQUARE

⊗ RADAR TARGET OUTSIDE ICEBERG LIMIT

NOTE:
For more information:
www.navcen.uscg.gov/iip
www.ice-glaces.ec.gc.ca
Most Recent Reconnaissance:
Interior Iceberg Flight 14MAY17



NORTH AMERICAN ICE SERVICE (NAIS)

ICEBERG ANALYSIS FOR 1200 UTC

01 JUN 2017

ESTIMATED ICEBERG LIMIT

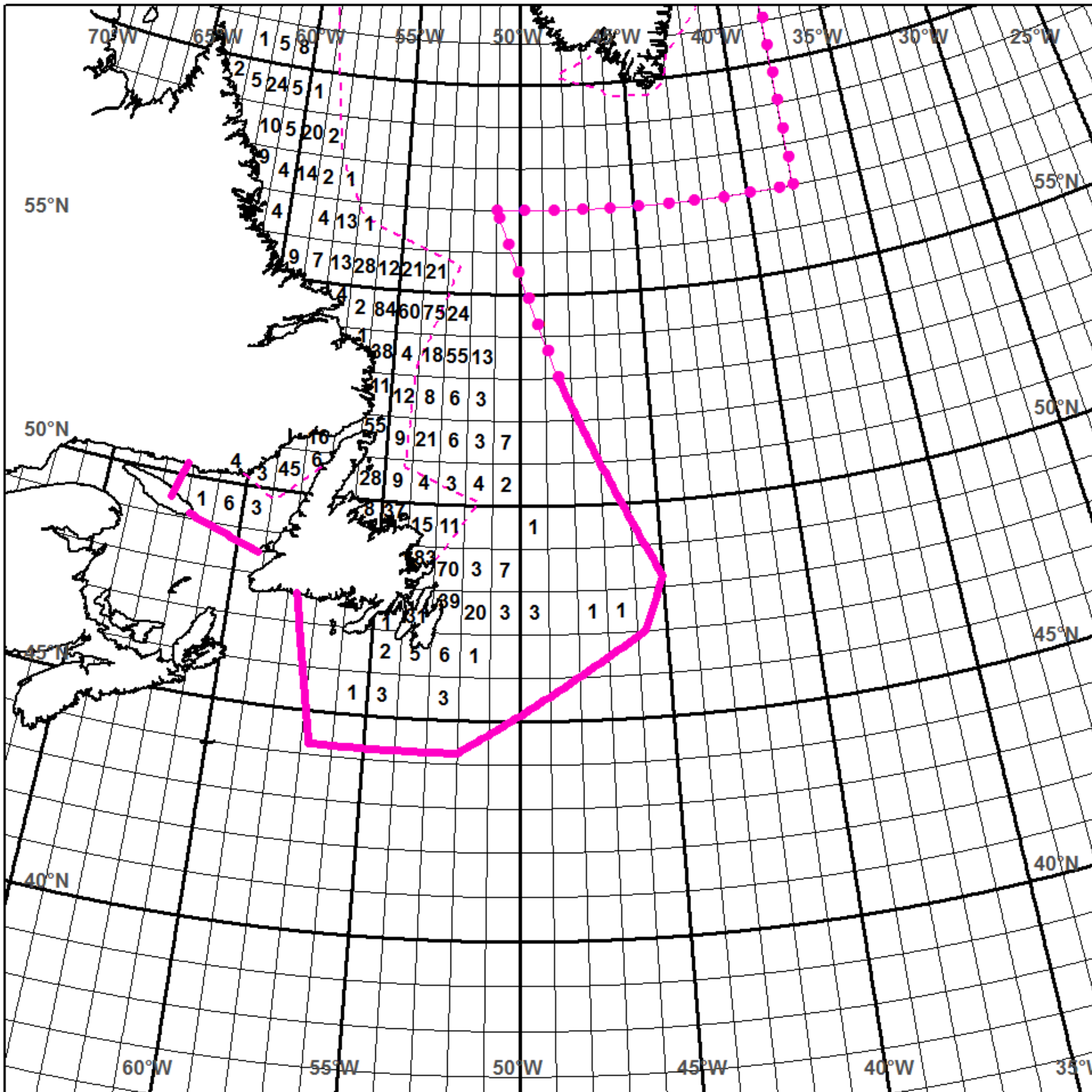
ICEBERG LIMIT

SEA ICE LIMIT

\# ICEBERGS PER DEGREE SQUARE

⊗ RADAR TARGET OUTSIDE ICEBERG LIMIT

NOTE:
For more information:
www.navcen.uscg.gov/iip
www.ice-glaces.ec.gc.ca
Most Recent Reconnaissance:
Interior General Flight 31MAY17.



NORTH AMERICAN ICE SERVICE (NAIS)

ICEBERG ANALYSIS FOR 0000 UTC

15 JUN 2017

ESTIMATED ICEBERG LIMIT

ICEBERG LIMIT

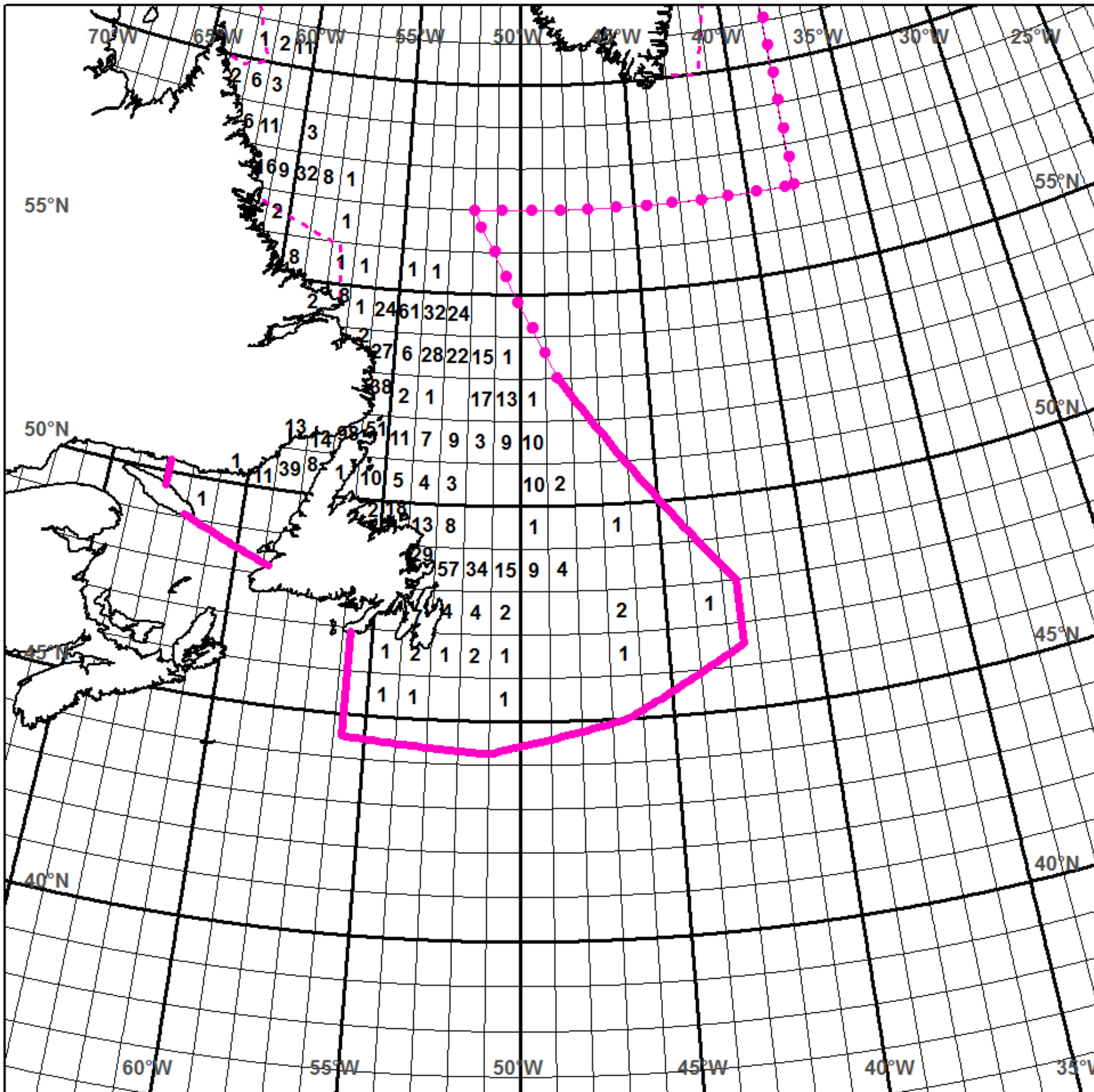
SEA ICE LIMIT

ICEBERGS PER DEGREE SQUARE

⊗ RADAR TARGET OUTSIDE ICEBERG LIMIT

NOTE:

For more information:
www.navcen.uscg.gov/iip
www.ice-glaces.ec.gc.ca
Most Recent Reconnaissance:
Interior General Flight 14JUN17.



NORTH AMERICAN ICE SERVICE (NAIS)

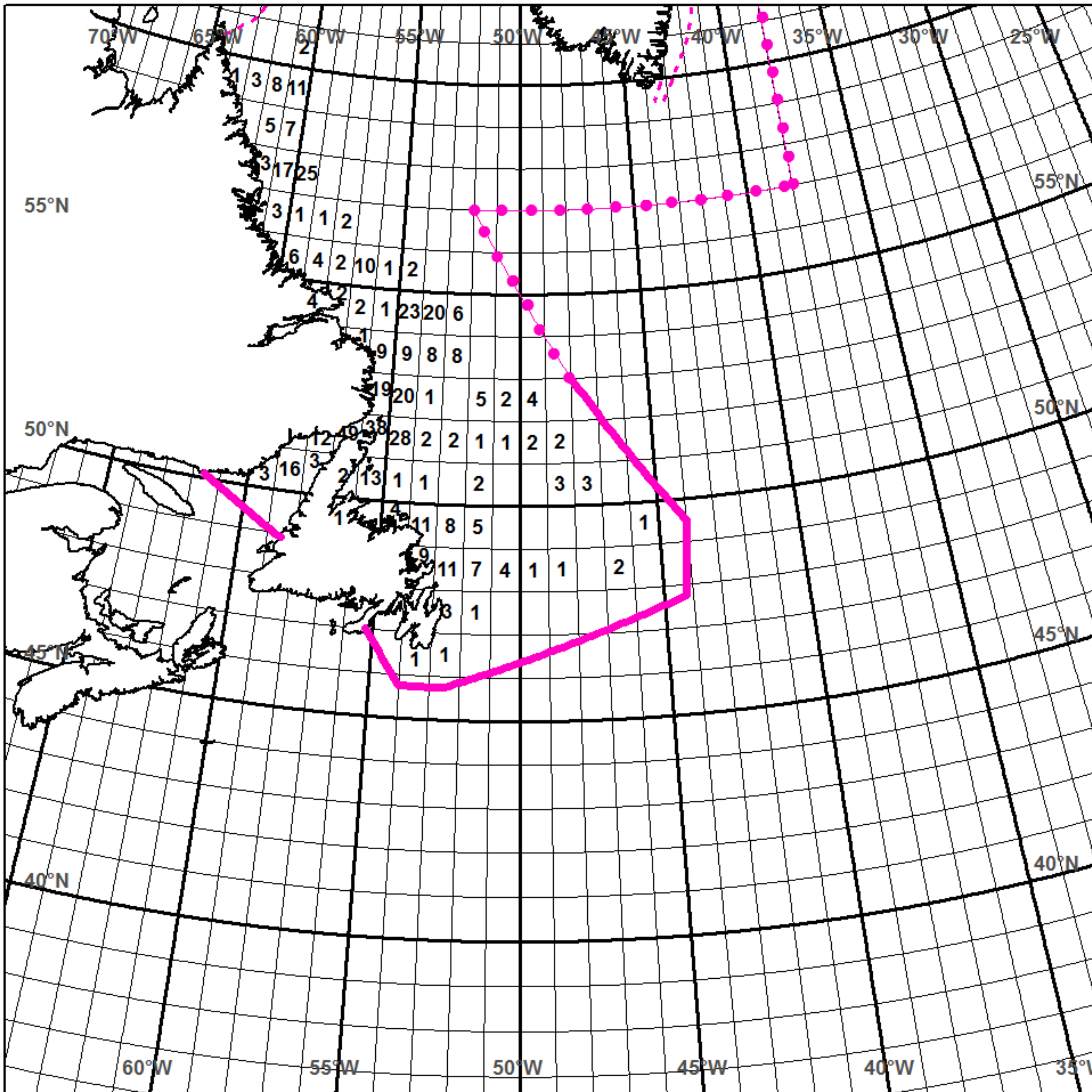
ICEBERG ANALYSIS FOR 0000 UTC

01 JUL 2017

- ESTIMATED ICEBERG LIMIT
- ICEBERG LIMIT
- SEA ICE LIMIT
- # ICEBERGS PER DEGREE SQUARE
- ⊗ RADAR TARGET OUTSIDE ICEBERG LIMIT

NOTE:

For more information:
www.navcen.uscg.gov/iip
www.ice-glaces.ec.gc.ca
Most Recent Reconnaissance:
Interior General Flight 29JUN17.



NORTH AMERICAN ICE SERVICE (NAIS)

ICEBERG ANALYSIS FOR 0000 UTC

15 JUL 2017

ESTIMATED ICEBERG LIMIT

ICEBERG LIMIT

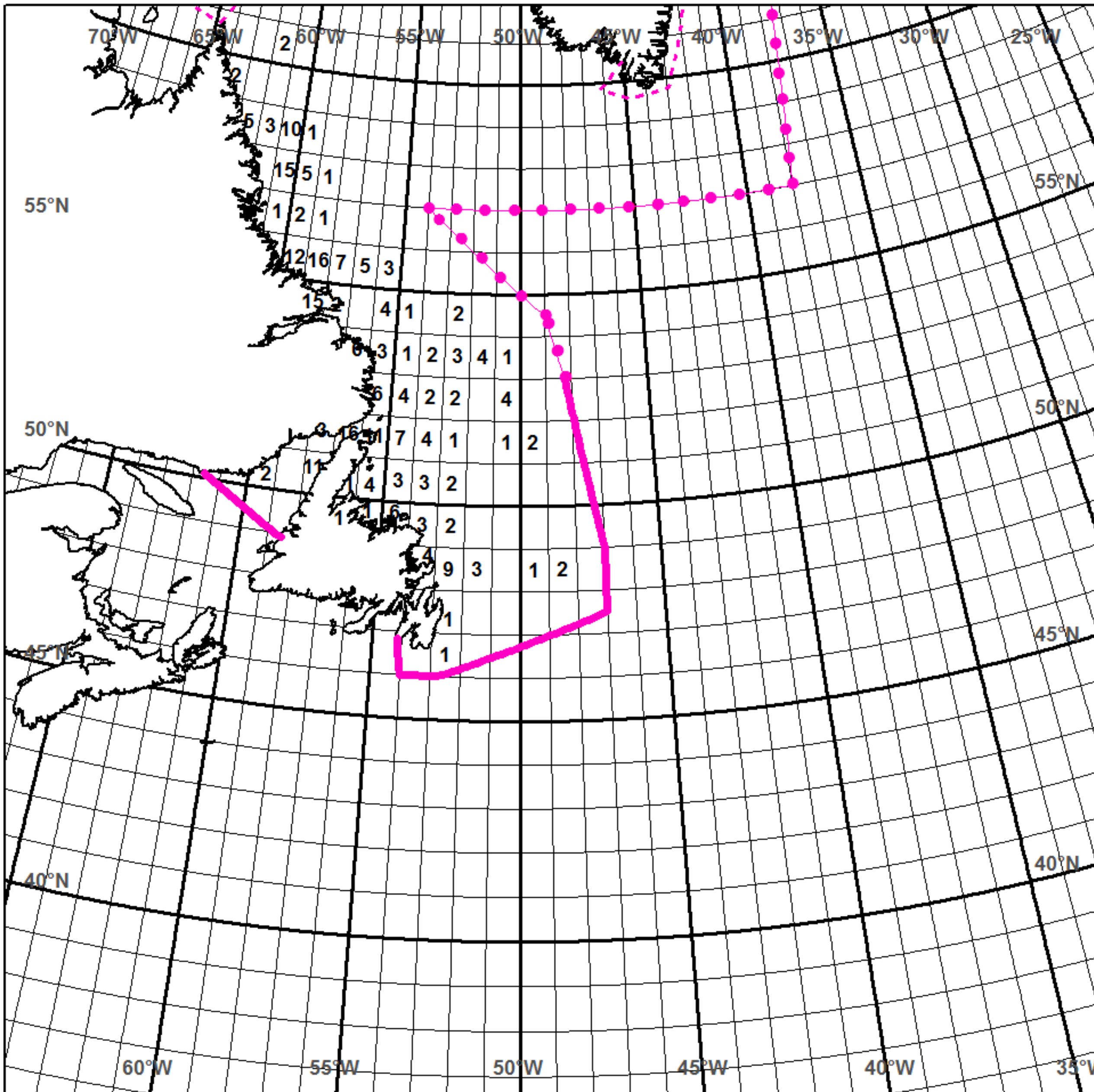
SEA ICE LIMIT

\# ICEBERGS PER DEGREE SQUARE

⊗ RADAR TARGET OUTSIDE ICEBERG LIMIT

NOTE:

For more information:
www.navcen.uscg.gov/iip
www.ice-glaces.ec.gc.ca
Most Recent Reconnaissance:
Southern Limit General Flight 13JUL17.



NORTH AMERICAN ICE SERVICE (NAIS)

ICEBERG ANALYSIS FOR 0000 UTC

01 AUG 2017

ESTIMATED ICEBERG LIMIT

ICEBERG LIMIT

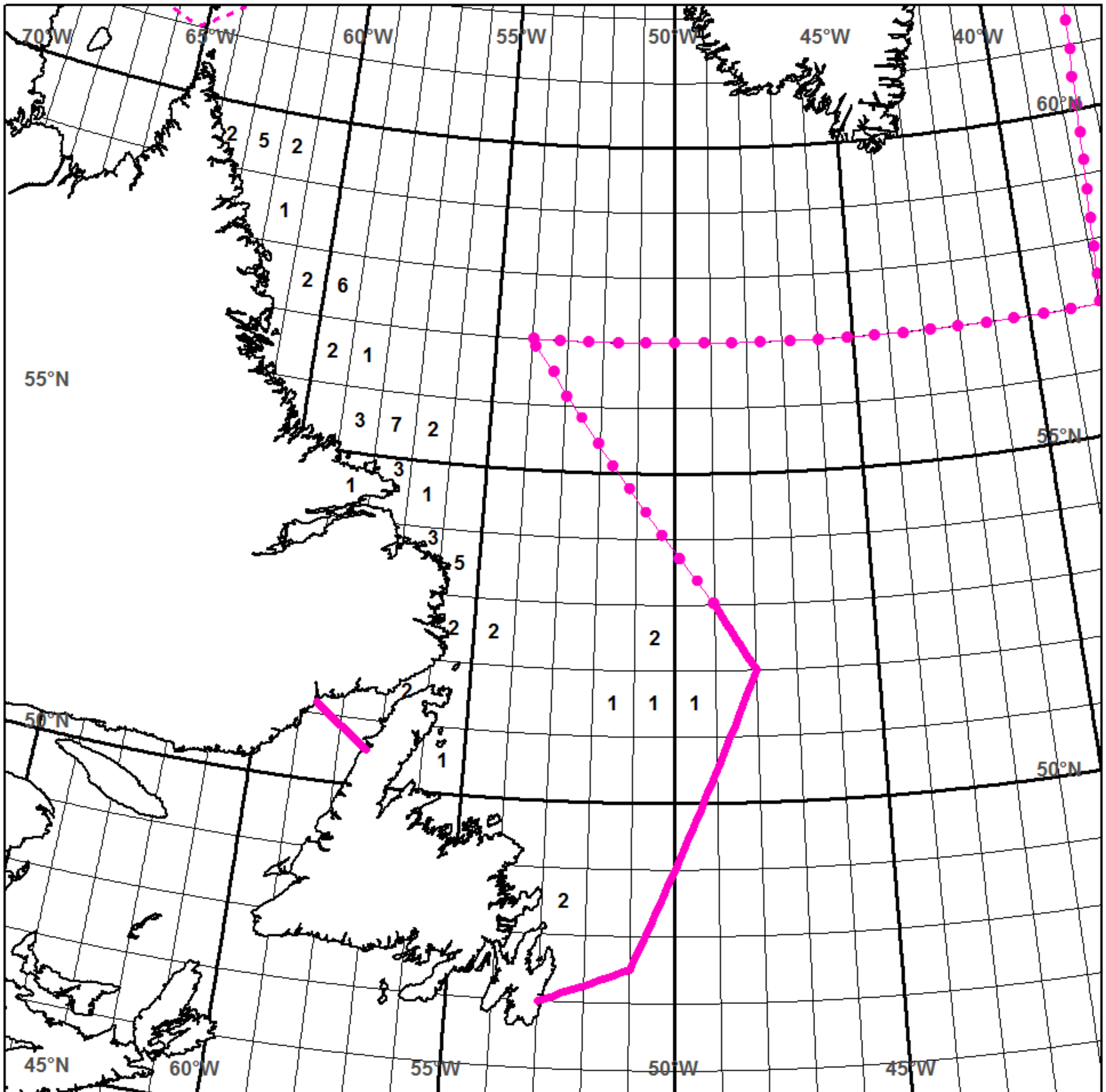
SEA ICE LIMIT

ICEBERGS PER DEGREE SQUARE

⊗ RADAR TARGET OUTSIDE ICEBERG LIMIT

NOTE:

For more information:
www.navcen.uscg.gov/iip
www.ice-glaces.ec.gc.ca
Most Recent Reconnaissance:
Western Limit Iceberg Flight 30JUL17.



NORTH AMERICAN ICE SERVICE (NAIS)

ICEBERG ANALYSIS FOR 0000 UTC

15 AUG 2017

ESTIMATED ICEBERG LIMIT

ICEBERG LIMIT

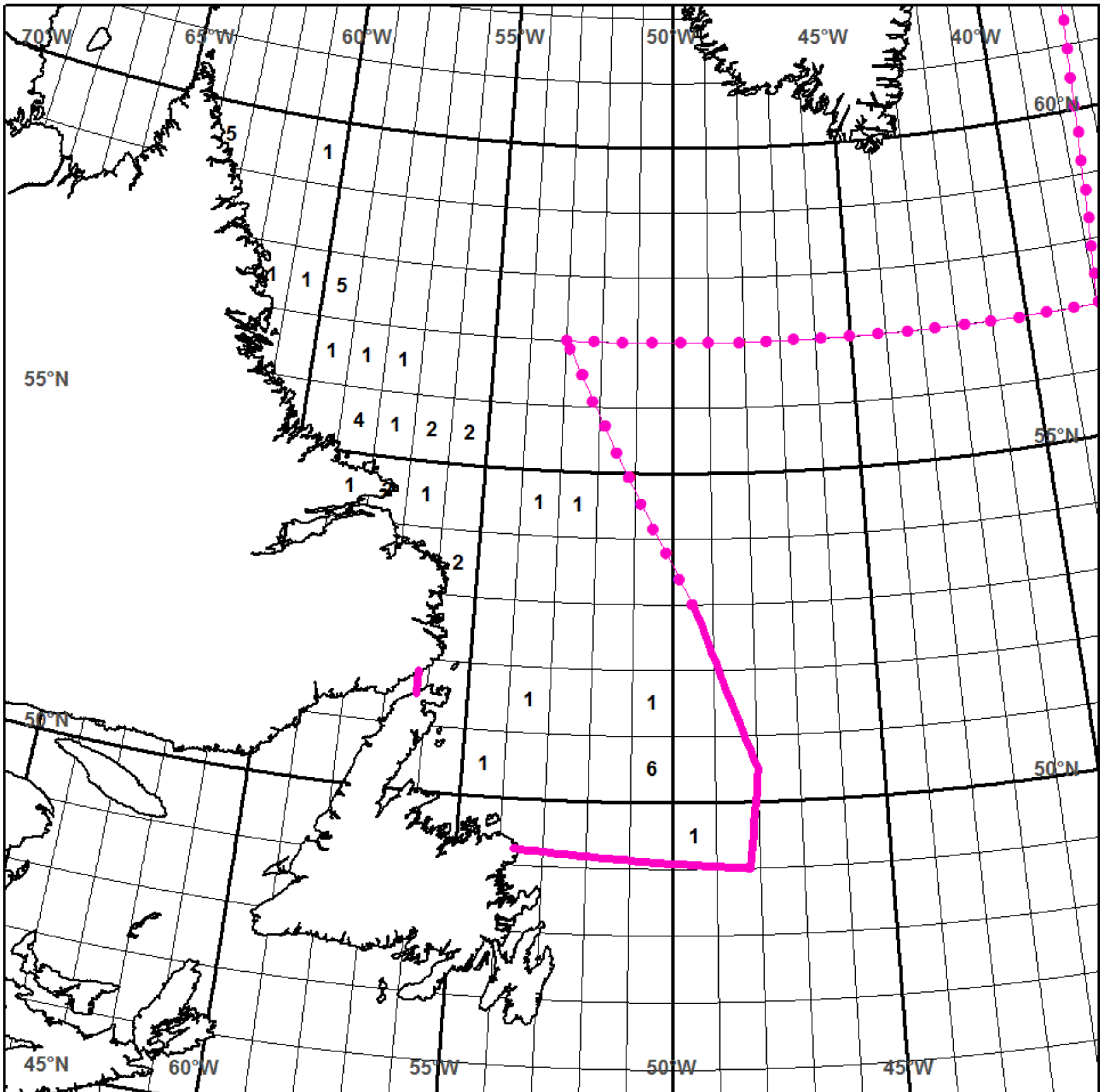
SEA ICE LIMIT

ICEBERGS PER DEGREE SQUARE

RADAR TARGET OUTSIDE ICEBERG LIMIT

NOTE:

For more information:
www.navcen.uscg.gov/iip
www.ice-glaces.ec.gc.ca
Most Recent Reconnaissance:
Interior General Flight 10AUG17.



NORTH AMERICAN ICE SERVICE (NAIS)

ICEBERG ANALYSIS FOR 0000 UTC

01 SEP 2017

ESTIMATED ICEBERG LIMIT

ICEBERG LIMIT

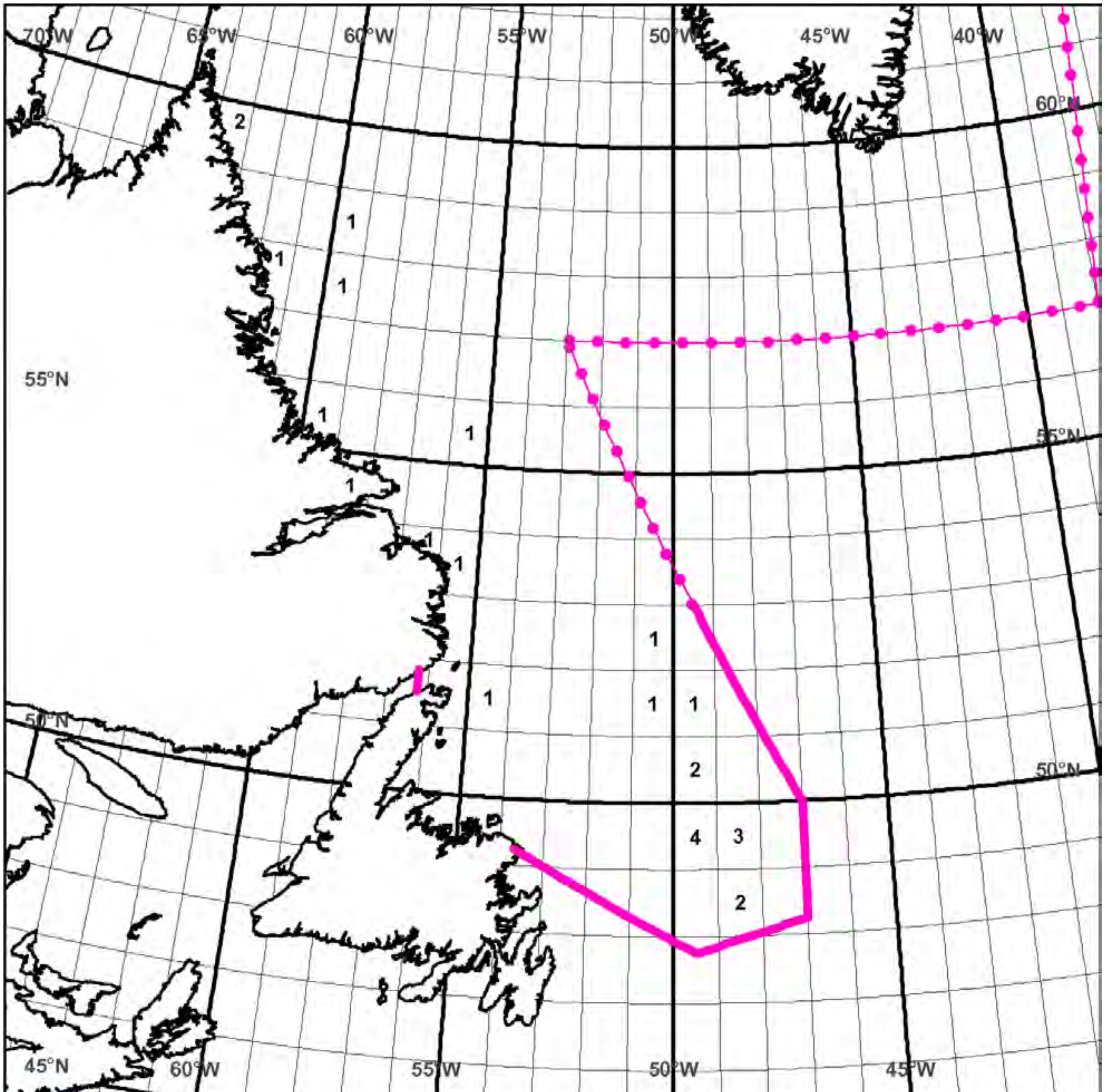
SEA ICE LIMIT

\# ICEBERGS PER DEGREE SQUARE

⊗ RADAR TARGET OUTSIDE ICEBERG LIMIT

NOTE:

For more information:
www.navcen.uscg.gov/iip
www.ice-glaces.ec.gc.ca
Most Recent Reconnaissance:
Interior Iceberg Flight 30AUG17.



NORTH AMERICAN ICE SERVICE (NAIS)

ICEBERG ANALYSIS FOR 0000 UTC

15 SEP 2017

ESTIMATED ICEBERG LIMIT

ICEBERG LIMIT

SEA ICE LIMIT

ICEBERGS PER DEGREE SQUARE

RADAR TARGET OUTSIDE ICEBERG LIMIT

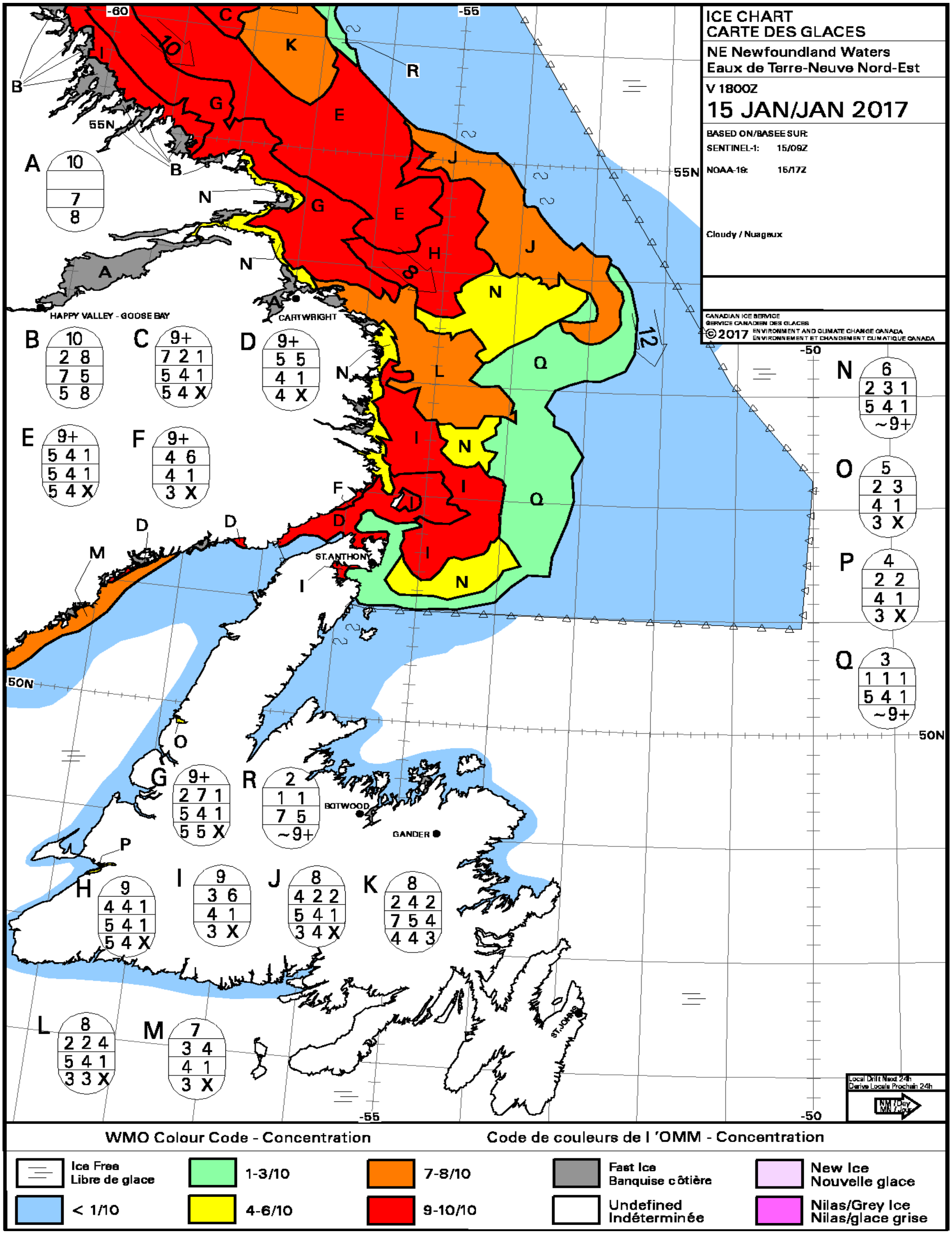
NOTE:

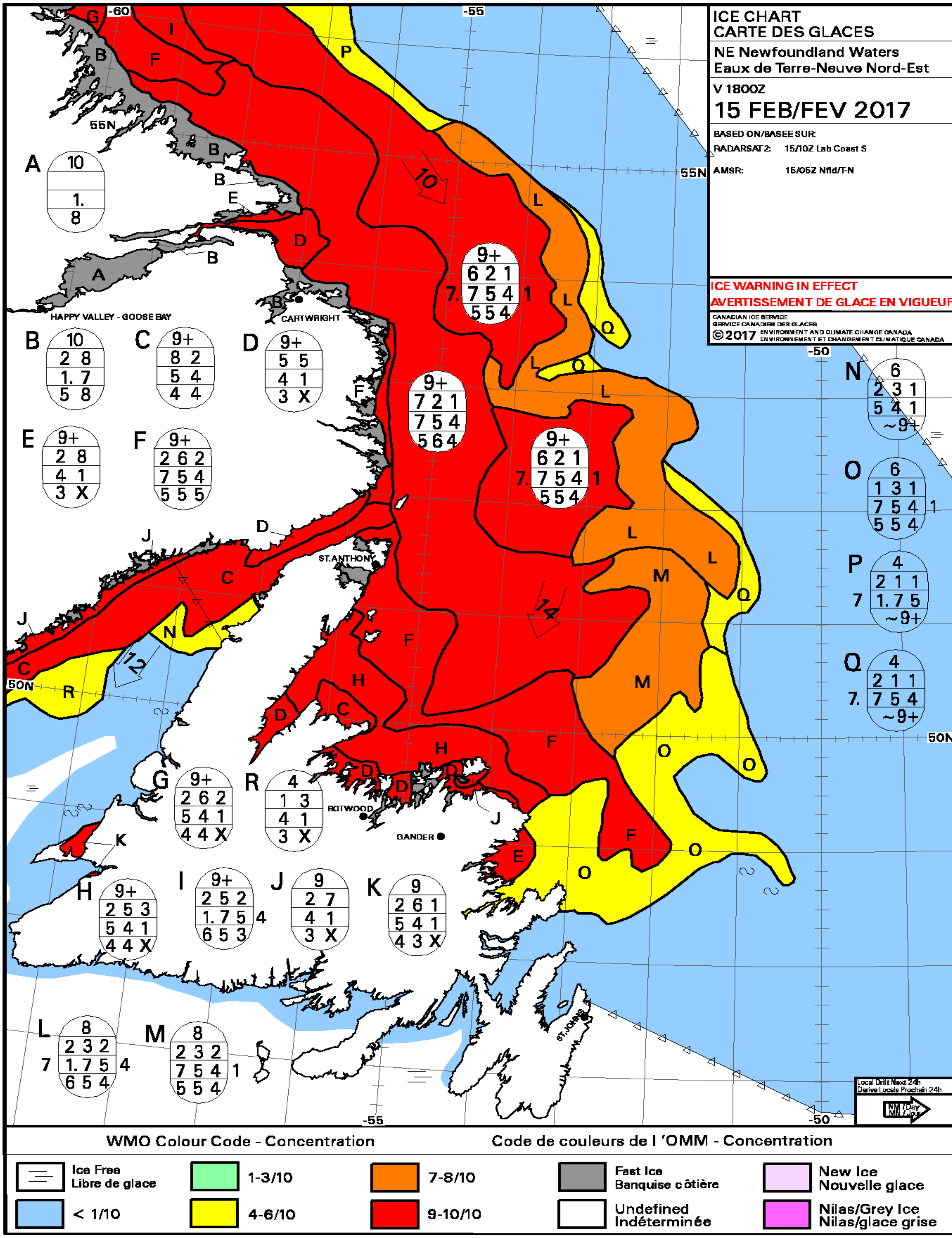
For more information:
www.navcen.uscg.gov/iip
www.ice-glaces.ec.gc.ca
Most Recent Reconnaissance:
Southern Limit Satellite Pass 13SEP17.

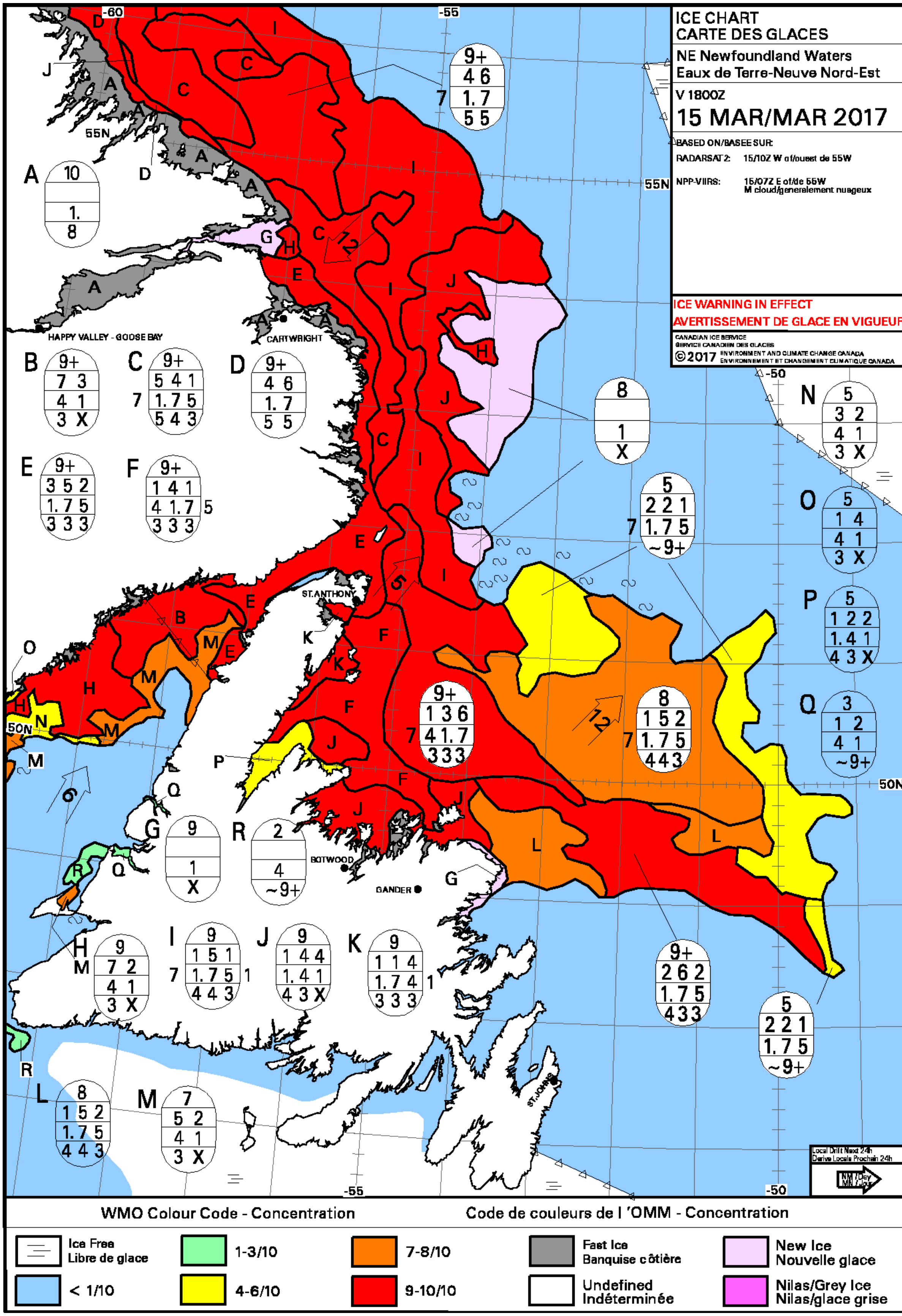
Monthly Sea Ice Charts

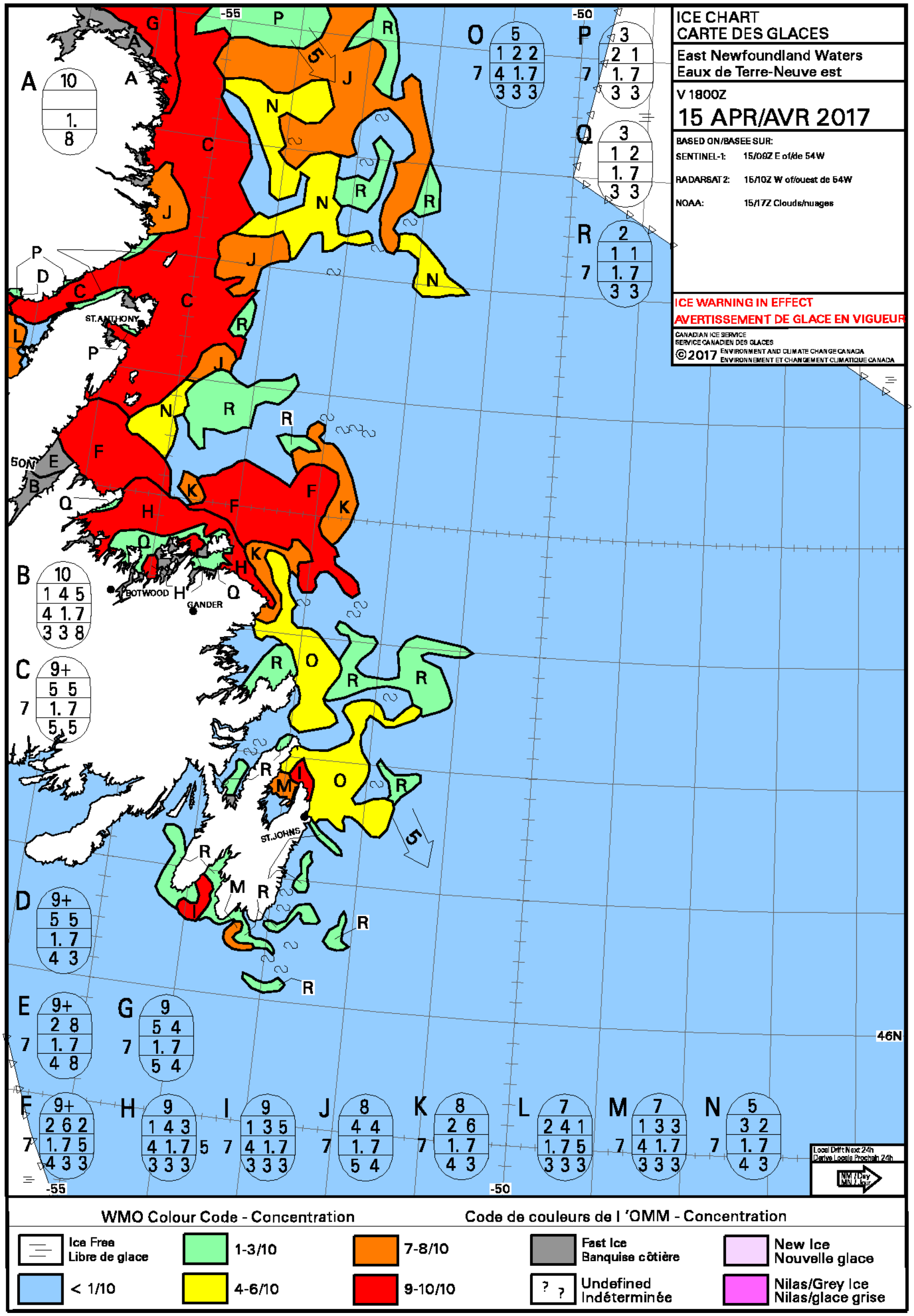
Sea ice charts are reprinted with permission of the Canadian Ice Service

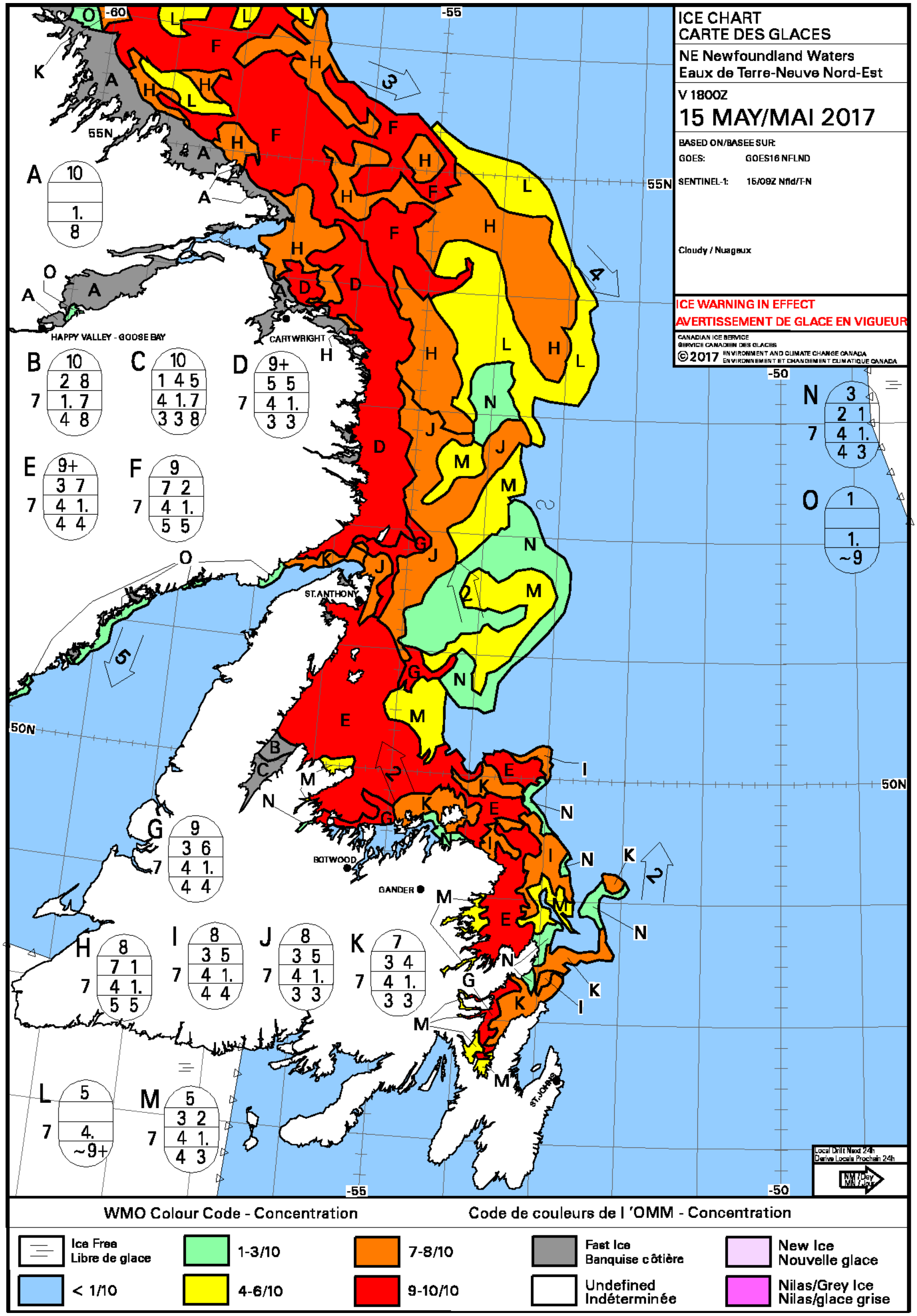
Sea ice symbols are in accordance with the World Meteorological Organization

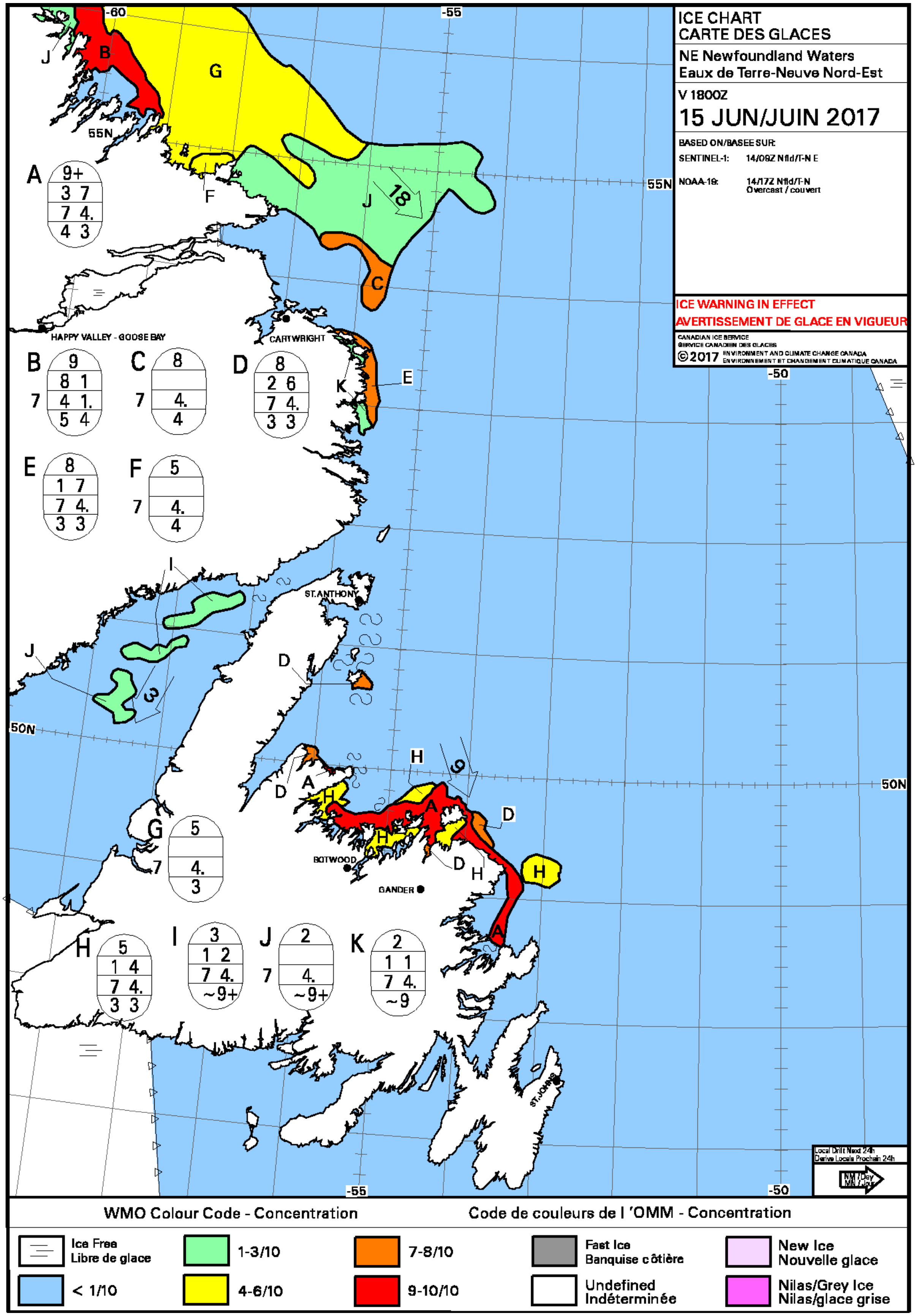

ICE CHART
CARTE DES GLACES
NE Newfoundland Waters
Eaux de Terre-Neuve Nord-Est
V 1800Z
15 JAN/JAN 2017
BASED ON/BASEE SUR:
SENTINEL-1: 15/09Z
NOAA-19: 15/17Z
Cloudy / Nuageux
CANADIAN ICE SERVICE
SERVICE CANADIEN DES GLACES
©2017 ENVIRONMENT AND CLIMATE CHANGE CANADA
ENVIRONNEMENT ET CHANGEMENT CLIMATIQUE CANADA
HAPPY VALLEY - GOOSE BAY
CARTWRIGHT
ST.ANTHONY
BOTWOOD
GANDER
ST.JOHNS
Local Drift Next 24h
Derive Locale Prochain 24h
WMO Colour Code - Concentration
Code de couleurs de l 'OMM - Concentration
Ice Free
Libre de glace
< 1/10
1-3/10
4-6/10
7-8/10
9-10/10
Fast Ice
Banquise côtière
Undefined
Indéterminée
New Ice
Nouvelle glace
Nilas/Grey Ice
Nilas/glace grise


ICE CHART
CARTE DES GLACES
NE Newfoundland Waters
Eaux de Terre-Neuve Nord-Est
V 1800Z
15 FEB/FEV 2017
BASED ON/BASEE SUR:
RADARSAT 2: 15/10Z Lab Coast S
AMSR: 15/05Z Nfld/T-N
ICE WARNING IN EFFECT
AVERTISSEMENT DE GLACE EN VIGUEUR
CANADIAN ICE SERVICE
SERVICE CANADIEN DES GLACES
©2017 ENVIRONMENT AND CLIMATE CHANGE CANADA
ENVIRONNEMENT ET CHANGEMENT CLIMATIQUE CANADA
HAPPY VALLEY - GOOSE BAY
CARTWRIGHT
ST. ANTHONY
BOTWOOD
GANDER
ST. JOHN'S
55N
50N
-60
-55
-50
Local Drift Next 24h
Derive Locale Prochain 24h
WMO Colour Code - Concentration
Code de couleurs de l 'OMM - Concentration
Ice Free
Libre de glace
< 1/10
1-3/10
4-6/10
7-8/10
9-10/10
Fast Ice
Banquise côtière
Undefined
Indéterminée
New Ice
Nouvelle glace
Nilas/Grey Ice
Nilas/glace grise

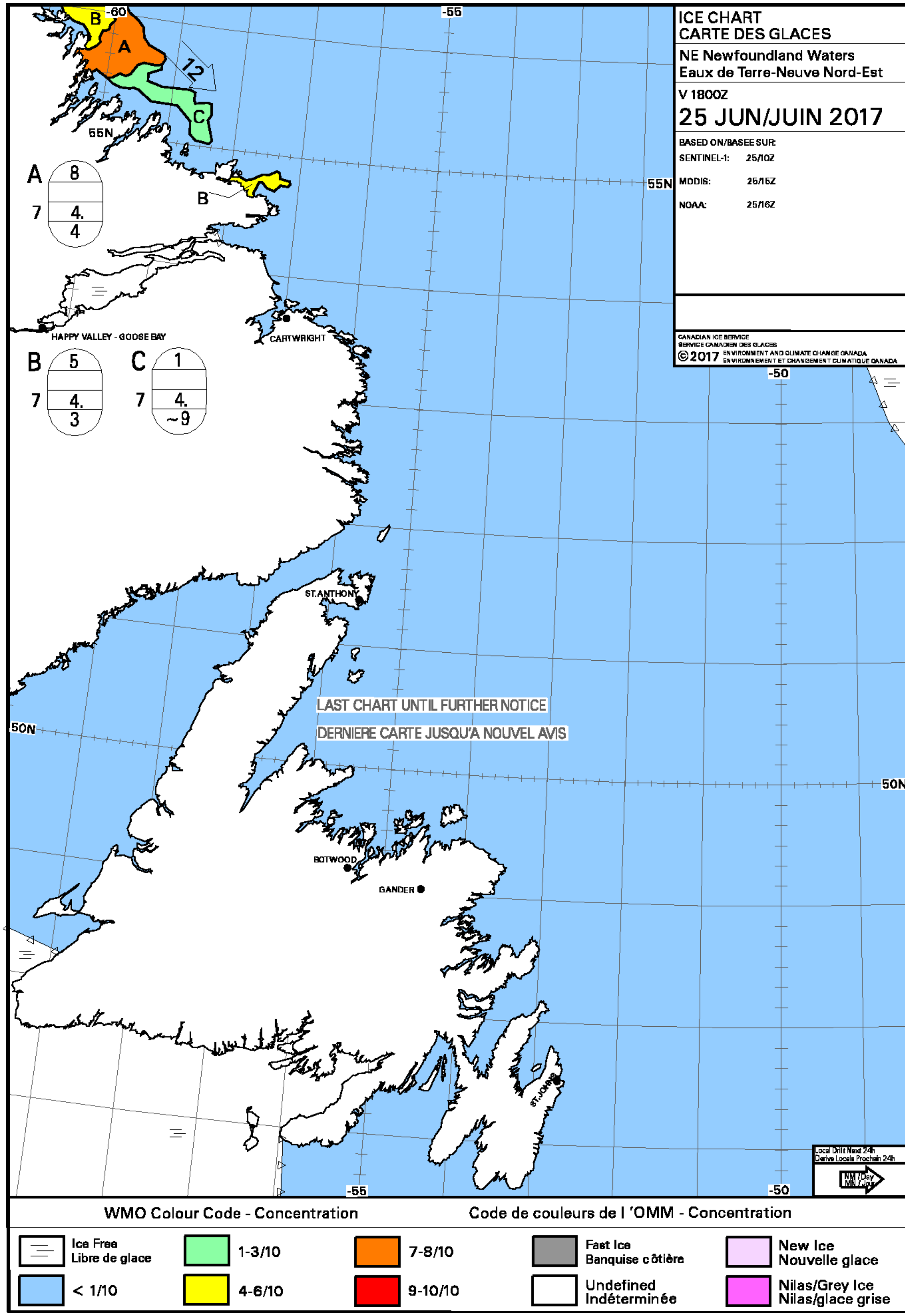

ICE CHART
CARTE DES GLACES
NE Newfoundland Waters
Eaux de Terre-Neuve Nord-Est
V 1800Z
15 MAR/MAR 2017
BASED ON/BASEE SUR:
RADARSAT 2: 15/10Z W of/ouest de 55W
NPP-VIIRS: 15/07Z E of/de 55W
M cloud/generalement nuageux
ICE WARNING IN EFFECT
AVERTISSEMENT DE GLACE EN VIGUEUR
CANADIAN ICE SERVICE
SERVICE CANADIEN DES GLACES
©2017 ENVIRONMENT AND CLIMATE CHANGE CANADA
ENVIRONNEMENT ET CHANGEMENT CLIMATIQUE CANADA
HAPPY VALLEY - GOOSE BAY
CARTWRIGHT
ST.ANTHONY
BOTWOOD
GANDER
ST.JOHN'S
55N
50N
-60
-55
-50
Local Drift Next 24h
Derive Locale Prochain 24h
NM/Day
MN/Jour
WMO Colour Code - Concentration
Code de couleurs de l 'OMM - Concentration
Ice Free
Libre de glace
< 1/10
1-3/10
4-6/10
7-8/10
9-10/10
Fast Ice
Banquise côtière
Undefined
Indéterminée
New Ice
Nouvelle glace
Nilas/Grey Ice
Nilas/glace grise

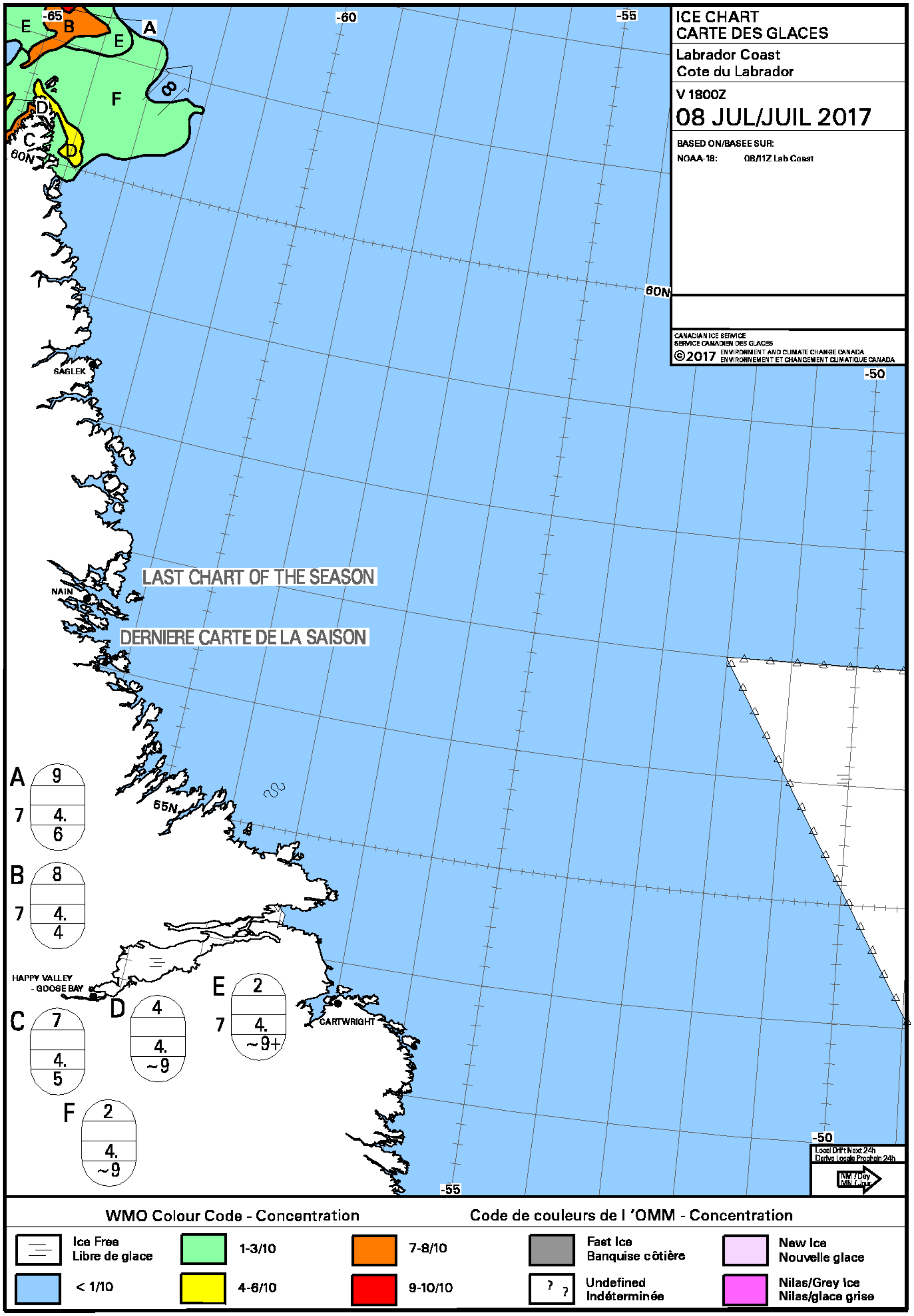

ICE CHART
CARTE DES GLACES
East Newfoundland Waters
Eaux de Terre-Neuve est
V 1800Z
15 APR/AVR 2017
BASED ON/BASEE SUR:
SENTINEL-1: 15/09Z E of/de 54W
RADARSAT 2: 15/10Z W of/ouest de 54W
NOAA: 15/17Z Clouds/nuages
ICE WARNING IN EFFECT
AVERTISSEMENT DE GLACE EN VIGUEUR
CANADIAN ICE SERVICE
SERVICE CANADIEN DES GLACES
©2017 ENVIRONMENT AND CLIMATE CHANGE CANADA
ENVIRONNEMENT ET CHANGEMENT CLIMATIQUE CANADA
ST.ANTHONY
BOTWOOD
GANDER
ST.JOHNS
50N
46N
-55
-50
WMO Colour Code - Concentration
Code de couleurs de l 'OMM - Concentration
Ice Free
Libre de glace
< 1/10
1-3/10
4-6/10
7-8/10
9-10/10
Fast Ice
Banquise côtière
Undefined
Indéterminée
New Ice
Nouvelle glace
Nilas/Grey Ice
Nilas/glace grise


ICE CHART
CARTE DES GLACES
NE Newfoundland Waters
Eaux de Terre-Neuve Nord-Est
V 1800Z
15 MAY/MAI 2017
BASED ON/BASEE SUR:
GOES: GOES16 NFLND
SENTINEL-1: 15/09Z Nfld/T-N
Cloudy / Nuageux
ICE WARNING IN EFFECT
AVERTISSEMENT DE GLACE EN VIGUEUR
CANADIAN ICE SERVICE
SERVICE CANADIEN DES GLACES
©2017 ENVIRONMENT AND CLIMATE CHANGE CANADA
ENVIRONNEMENT ET CHANGEMENT CLIMATIQUE CANADA
HAPPY VALLEY - GOOSE BAY
CARTWRIGHT
ST. ANTHONY
BOTWOOD
GANDER
ST. JOHN'S
55N
50N
-60
-55
-50
WMO Colour Code - Concentration
Code de couleurs de l 'OMM - Concentration
Ice Free
Libre de glace
< 1/10
1-3/10
4-6/10
7-8/10
9-10/10
Fast Ice
Banquise côtière
Undefined
Indéterminée
New Ice
Nouvelle glace
Nilas/Grey Ice
Nilas/glace grise



ICE CHART
CARTE DES GLACES
NE Newfoundland Waters
Eaux de Terre-Neuve Nord-Est
V 1800Z
15 JUN/JUIN 2017
BASED ON/BASEE SUR:
SENTINEL-1: 14/09Z Nfld/T-N E
NOAA-18: 14/17Z Nfld/T-N Overcast / couvert
ICE WARNING IN EFFECT
AVERTISSEMENT DE GLACE EN VIGUEUR
CANADIAN ICE SERVICE
SERVICE CANADIEN DES GLACES
©2017 ENVIRONMENT AND CLIMATE CHANGE CANADA
ENVIRONNEMENT ET CHANGEMENT CLIMATIQUE CANADA
HAPPY VALLEY - GOOSE BAY
CARTWRIGHT
ST.ANTHONY
BOTWOOD
GANDER
ST.JOHNS
55N
50N
-60
-55
-50
Local Drift Next 24h
Dérive Locale Prochain 24h
WMO Colour Code - Concentration
Code de couleurs de l 'OMM - Concentration
Ice Free
Libre de glace
< 1/10
1-3/10
4-6/10
7-8/10
9-10/10
Fast Ice
Banquise côtière
Undefined
Indéterminée
New Ice
Nouvelle glace
Nilas/Grey Ice
Nilas/glace grise


ICE CHART
CARTE DES GLACES
NE Newfoundland Waters
Eaux de Terre-Neuve Nord-Est
V 1800Z
25 JUN/JUIN 2017
BASED ON/BASEE SUR:
SENTINEL-1: 25/10Z
MODIS: 25/15Z
NOAA: 25/16Z
CANADIAN ICE SERVICE
SERVICE CANADIEN DES GLACES
©2017 ENVIRONMENT AND CLIMATE CHANGE CANADA
ENVIRONNEMENT ET CHANGEMENT CLIMATIQUE CANADA
LAST CHART UNTIL FURTHER NOTICE
DERNIERE CARTE JUSQU'A NOUVEL AVIS
HAPPY VALLEY - GOOSE BAY
CARTWRIGHT
ST.ANTHONY
BOTWOOD
GANDER
ST.JOHN'S
55N
50N
-60
-55
-50
Local Drift Next 24h
Derive Locale Prochain 24h
WMO Colour Code - Concentration
Code de couleurs de l 'OMM - Concentration
Ice Free
Libre de glace
< 1/10
1-3/10
4-6/10
7-8/10
9-10/10
Fast Ice
Banquise côtière
Undefined
Indéterminée
New Ice
Nouvelle glace
Nilas/Grey Ice
Nilas/glace grise


ICE CHART
CARTE DES GLACES
Labrador Coast
Cote du Labrador
V 1800Z
08 JUL/JUIL 2017
BASED ON/BASEE SUR:
NOAA-18: 08/11Z Lab Coast
CANADIAN ICE SERVICE
SERVICE CANADIEN DES GLACES
©2017 ENVIRONMENT AND CLIMATE CHANGE CANADA
ENVIRONNEMENT ET CHANGEMENT CLIMATIQUE CANADA
LAST CHART OF THE SEASON
DERNIERE CARTE DE LA SAISON
SAGLEK
NAIN
HAPPY VALLEY - GOOSE BAY
CARTWRIGHT
60N
55N
-65
-60
-55
-50
Local Drift Next 24h
Dérive Locale Prochain 24h
WMO Colour Code - Concentration
Code de couleurs de l 'OMM - Concentration
Ice Free
Libre de glace
< 1/10
1-3/10
4-6/10
7-8/10
9-10/10
Fast Ice
Banquise côtière
Undefined
Indéterminée
New Ice
Nouvelle glace
Nilas/Grey Ice
Nilas/glace grise

Acknowledgements

Commander, International Ice Patrol acknowledges the following organizations for providing information and assistance:

Canadian Coast Guard

Canadian Forces

Canadian Ice Service

Canadian Maritime Atlantic Command Meteorological and Oceanographic Centre

Canadian Meteorological Centre

Centre for Cold Ocean Resources Engineering Department of Fisheries and Oceans Canada

Danish Meteorological Institute

European Space Agency

German Federal Maritime and Hydrographic Agency

MacDonald, Dettwiler and Associates

National Geospatial-Intelligence Agency

Nav Canada Flight Information Center

NOAA

National Weather Service

PAL Aerospace, Ltd.

PAL Aviation Services

Transport Canada

USCG Air Station Elizabeth City

USCG Air Station Cape Cod

USCG Atlantic Area

USCG Aviation Training Center Mobile

USCG Director of Marine Transportation Systems

USCG Director of Intelligence and Criminal Investigations

USCG First District

USCG Maritime Fusion Intelligence Center Atlantic

USCG Navigation Center

USCG Research and Development Center

U.S. National Ice Center

U.S. Naval Fleet Numerical Meteorology and Oceanography Center

It is important to recognize the outstanding efforts of the personnel assigned to the International Ice Patrol during the 2017 Ice Year:

CDR K. L. Serumgard

CDR G. G. McGrath

LCDR J. C. Gatz

Mr. M. R. Hicks

Mrs. B. J. Lis

LCDR S. A. Koch

LCDR C. B. Bell

LT R. H. Clark

LT B. P. Dougherty

MSTCS K. E. Brockhouse

YN1 J. I. Vega

MST1 S. L. Skeen

MST1 S. A. Baumgartner

MST1 M. A. Connell

MST1 M. J. Harrell

MST2 D. M. Morrisey

MST2 B. M. Reel

MST2 J. J. Menard

MST2 R. M. Beal

MST3 Z. P. Kniskern

MST3 J. J. Paulk

MST3 J. L. Crocker

Appendix A

Ship Reports for Ice Year 2017

Ships Reporting by Flag Reports

BAHAMAS	
EUROPEAN SPIRIT	1
ATLANTIC EXPLORER	7
BERMUDA	
MONTREAL EXPRESS	1
CANADA	
ARCTIC	1
ATLANTIC ENTERPRISE	1
ATLANTIC KESTREL	3
CCG ALFRED NEEDLER	1
CCGS CAPE ROGER	2
CCGS SIR WILLIAM ALEXANDER	1
CCGS EDWARD COURNWALIS	1
ARLUK II	1
*CCGS GEORGE R. PEARKES	13
HEATHER KNUTSEN	2
EAST COAST	1
ATLANTIC LARCH	2
FUNDY LEGAND	1
NAVION HISPANIA	2
OCEANEX SANDERLING	5
UMIAK 1	5
CAYMAN ISLANDS	
SYCARA V	1
CYPRUS	
ISODORA	1
GIBRALTAR	
RANDZEL	2
HONG KONG	
OOCL MONTREAL	2
LIBERIA	
HIGH PRESENCE	1

MALTA	
CIELO DI MILANO	2
MARSHALL ISLANDS	
ALEXANDROS II	1
FEDERAL MAYUMI	1
FEDERAL TYNE	1
FEDERAL MOSEL	1
NAVE PULSAR	3
PYXIS DELTA	1
NETHERLANDS	
EEMSBORG	1
EXEBORG	1
FAIRMOUNT GLACIER	1
MARSGRACHT	1
MAERSK PALERMO	1
PANAMA	
AM CONTRECOEUR	1
PORTUGAL	
MONTE TOLEDO	1
UNITED STATES OF AMERICA	
NEIL ARMSTRONG	1

*Denotes the CARPATHIA award winner.

IIP formally recognizes the vessel that submits the most iceberg reports each year with the CARPATHIA Award. The award is named after the RMS CARPATHIA, the vessel credited with rescuing 705 survivors from the RMS TITANIC disaster.